COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

February, 1950

Neches Station of Gulf States Utilities Company; see page 40

40,000-Kw Extension to Neches Power Station

New Water Treating System Produces CO_2-Free Steam, Part I

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Feature Articles

Editorials

Departments

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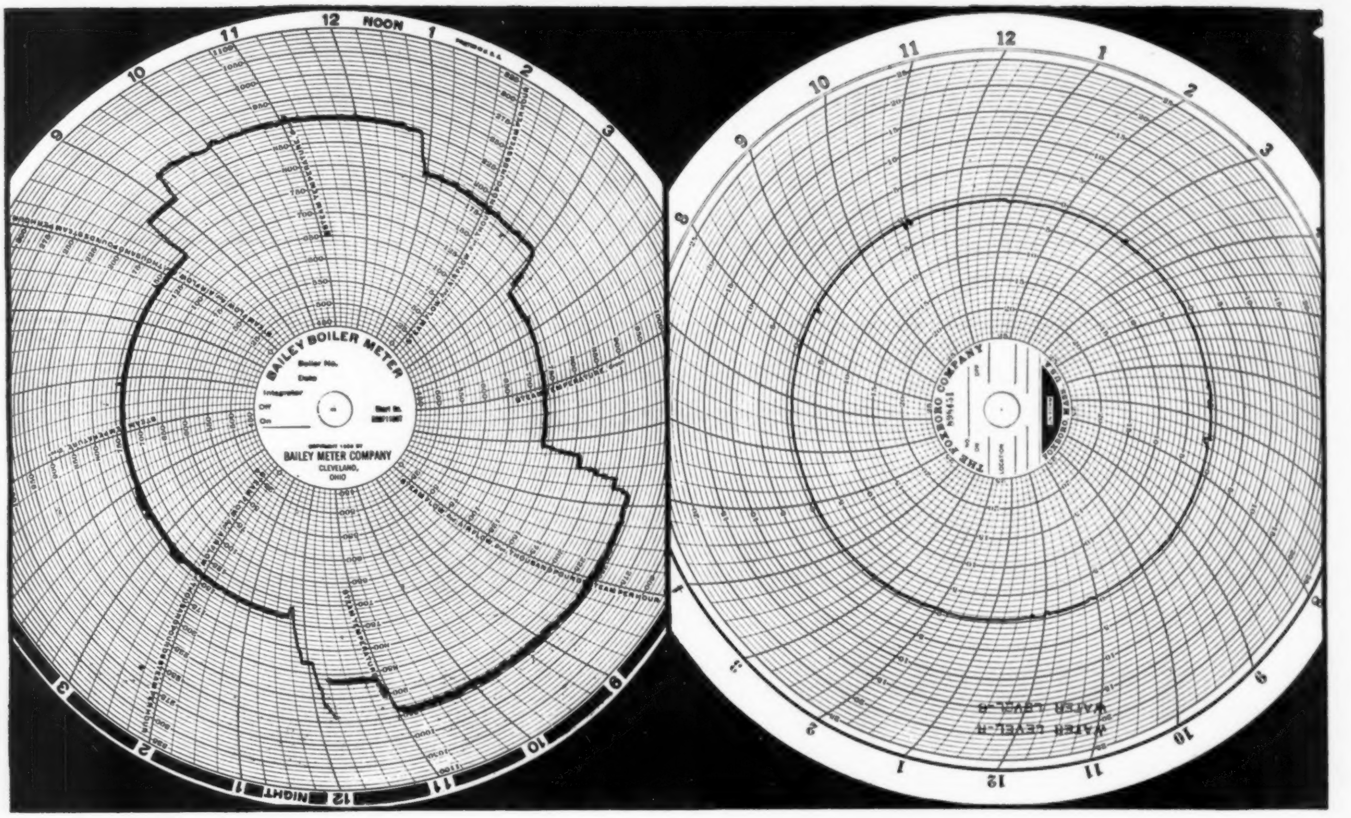

Left: Steam flow from B & W Type FH Boiler rated at 275,000 pounds per hour, 900 psi, 910 F. Right: Drum level held within ±½ inch by COPES Flowmatic

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COMBUSTION

Editorials

The Myth of Security

Combining audacity with sincerity, an engineering college senior interjected a thought at a recent national engineering meeting that must have caused his elders to pause to wonder. For nearly two and a half hours at this particular session, training and adjustment of the young engineer had been the subject of well-considered papers by authorities on industry-fostered education. While some misgivings were expressed concerning attitudes of the present college generation, it remained for this student to express what appears to be foremost in the minds of many young men of today—*security*. He added, in effect, "I want to take care of myself first; and after I am secure, then I may desire to participate in community affairs."

Thoughtful reflection will readily disclose that there must be a distinction between economic security and internal personal security, sometimes described as "peace of mind." But even if this is apparent to the mature mind, how can it be put across to impetuous youth and, more pointedly, to the ex-GI's who are "fed up" with taking advice, however kindly meant?

One of two ways in which young engineers will *not* achieve understanding of the crux of the security problem is through expressions of righteous indignation by their elders. Another fallacious way lies in the attempt to ignore the reality of their attitudes and the seriousness of their desires for security. If the experienced engineer and the wise executive are unwilling to face these issues, they can be sure that the labor leader and the left-wing politician will exploit them fully —and in a manner that may leave cause for regret in the future.

What is the answer? One may gather a clue by recalling his own personal feelings as he left the sheltered academic campus and embarked upon an uncertain engineering career. Certainly, times were different then, but who wasn't beset by misgivings toward the future? And who didn't long to hold a job that would provide some of the rewards and satisfactions of normal family life? Times haven't changed in so far as these normal human aspirations are concerned, but it must be remembered that the present generation of young engineers has lived through the troublesome era following a major depression and a world-wide conflict.

To assume that such an upsetting series of events has had no effect upon youthful thinking and desires is folly. This, in turn, suggests what the experienced engineer must be prepared to do. As young engineers enter an organization, or as opportunities are offered to contact them in the colleges or through professional society activities, they should be taken into the confidence of more experienced engineers and made to feel a sense of pride in belonging to the engineering profession. One should not be surprised if they reveal a lot of "half-baked" ideas, but recent graduates are usually eager to learn from one they can respect as a person who really "knows the score" on engineering practice.

The myth of security is likely to disappear as the penetrating light of realism is thrown in its direction. Young engineers are intelligent individuals who have been taught the difference between statics and dynamics, and it should not be impossible nor difficult to convince them that security is an illusory static concept. In a nation dedicated to the free-enterprise system and in a world that is ever changing, the ultimate price of security is economic stagnation and endless bureaucracy. Can it possibly be that the ambitions and aspirations of the engineering leaders of tomorrow are aimed no higher than that?

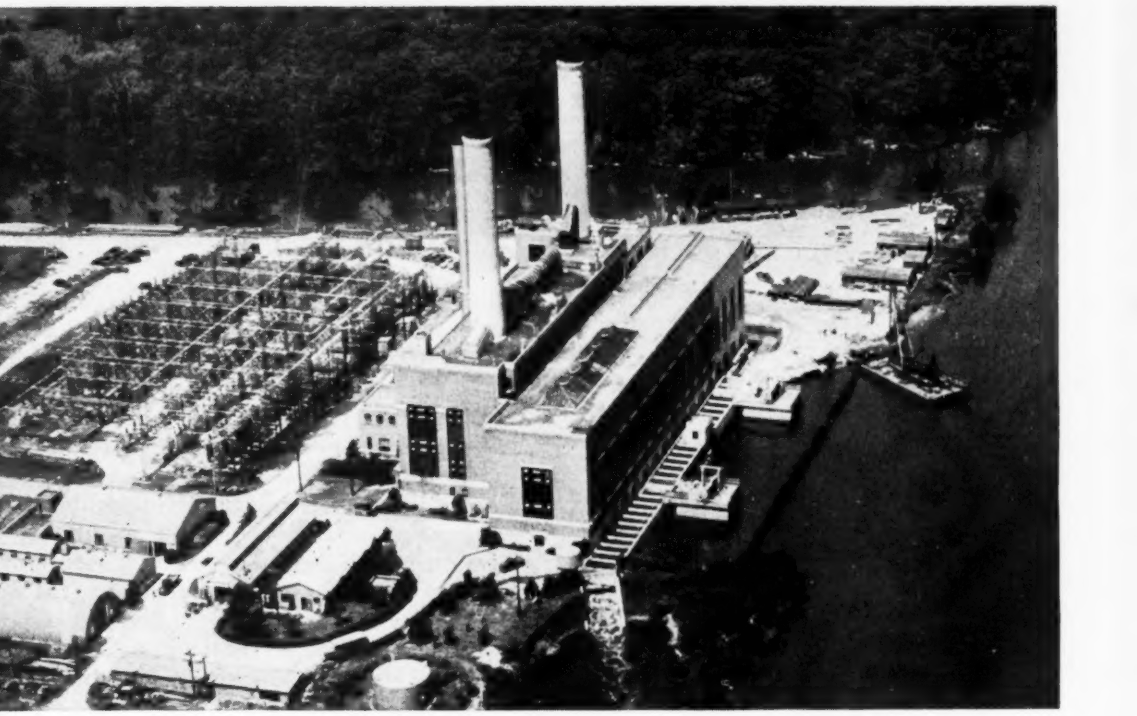
Superheat

Speaking before the Metropolitan Section of the A.S.M.E. on February first, representatives of the three largest boiler manufacturers discussed "superheat" from the standpoints of design factors, present practice and possible trends. While, as might be expected, their respective papers differed somewhat as to means of attaining and controlling the end result, there was general agreement on the basic problems involved and the economic outlook.

With superheat dominating the design of a modern steam generating unit, increase in maximum steam temperature has not been as rapid as one might offhand assume; that is, in the last decade it has not exceeded an *average* of about fifteen degrees per year. Moreover, it has followed closely upon advances in metallurgy and welding practice within the limits of economic justification.

Several stations are now operating satisfactorily with total steam temperatures of 1050 F, and designers are confident that still higher temperatures are feasible with materials now commercially available, but economics and inherent engineering caution appear to exert a restraining influence. On the economic side, it is not alone the cost of materials entering into the superheater, for this concerns only the finishing loops, but also the fact that austenitic materials would be required for the piping system. As to caution, there is some reluctance to advance too rapidly with large units whose outage is expensive; but instead, to gain step-by-step experience and also to profit by the results of certain research projects that are now under way.

Meanwhile the widening employment of reheat, in conjunction with currently high initial steam temperatures, is calculated to achieve results in station performance comparable to much higher steam temperatures with the straight regenerative cycle. This, of course, does not mean that the limit has been reached.



Aerial view of Neches Station

40,000-Kw Extension to Neches Power Station of Gulf States Utilities Company

By A. KIRKPATRICK

Mechanical Engineer, Stone & Webster Engineering Corp.

GULF States Utilities Company furnishes electricity to a large area, comprising some 270 communities, in southeastern Texas and the south central portion of Louisiana. In addition, it distributes natural gas to many localities, and steam and power to a group of industrials in Baton Rouge, La.

In all, the Company operates five steam plants and three internal-combustion-engine plants, with an aggregate capacity of 330,500 kw, which will shortly be increased considerably by completion of new units now under construction.

The more important steam plants are: Neches, near Beaumont, Tex., with a present capacity of 125,000 kw and 60,000 kw on order; Riverside Station at Lake Charles, containing 40,000 kw with a second unit of like capacity scheduled to go in service this year; and the Louisiana Station at Baton Rouge, La., with an electric generating capacity of 148,500 kw, including one 40,000-kw unit placed in service in January 1950. A second 40,000-kw unit is now under construction. This last-mentioned plant, built in 1930 and subsequently extended, recently had added a 500,000-lb per hr boiler to augment its process steam supply to a refinery and local chemical plants. The present article will deal only with the 1947 extension to Neches Station, which went into commercial operation in April 1949.

Neches Station is situated on the Neches River about two miles southeast of Beaumont, Tex., where ample condensing water is available for some 300,000 kw. Initially laid down in 1925, with one 20,000-kw, 350-psi, 700-F main unit, it was extended in 1927 by the addition of 35,000 kw, and ten years later by installation of a 320,000-lb per hr, 850-psi, 900-F boiler and a 25,000-kw turbine-generator; the 1947 extension added a 400,000-lb per hr boiler and a 40,000-kw, 850-psi, 900-F turbine-generator; and there is now on order a 600,000-lb per hr boiler and 60,000-kw turbine-generator. Thus the present rated capacity is 120,000 kw (or 125,000 kw, including three auxiliary units used for station service), and by 1951 will have reached 180,000 kw.

The fuel has always been natural gas with oil as a standby. This gas, of 1060 Btu per cu ft heating value, is piped to the plant under a pressure of 350 psi. The oil reserve of 4400 bbl is stored in tanks.

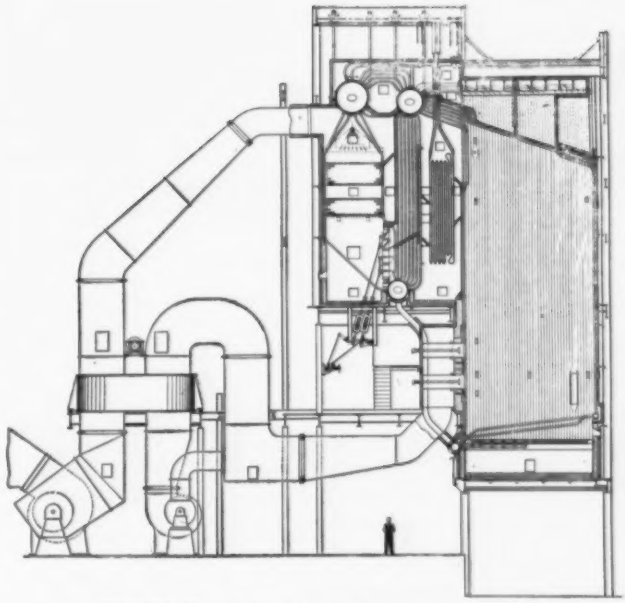
The 1947 extension employs the unit system of steam generating unit and turbine-generator and is not tied in with the other portion of the plant, except for electrical connections, fuel piping, auxiliary steam and circulating water intake and discharge. The boiler room was extended approximately 65 ft to accommodate the new unit and for convenience the firing aisle was made continuous with that of the old boilers. Although the boiler is housed, the fans, air preheater and flues are outside, as shown in the accompanying cross-section. Also, the turbine room was extended 84 ft and a new switchhouse was constructed.

A 150-ft high, 9-ft diameter steel stack, flanged at the base and resting on a concrete mat at ground level serves the extension.

Steam Generating Unit

This consists of a 400,000-lb per hr, three-drum Combustion Engineering boiler having a completely water-cooled furnace and fired with six Peabody combination gas and oil burners, arranged in two vertical rows of three burners each; a pendant type Elesco superheater; and a Ljungstrom air preheater. Steam temperature at the superheater outlet is controlled automatically by two motor-operated dampers at the bottom of the second pass. These dampers can also be manually set from the control board. Except for the air preheater, no soot blowers are provided, although wall boxes have been installed. While the boiler is designed for 950 psig, the working pressure and temperature of the steam leaving the superheater is 875 psig and 910 F.

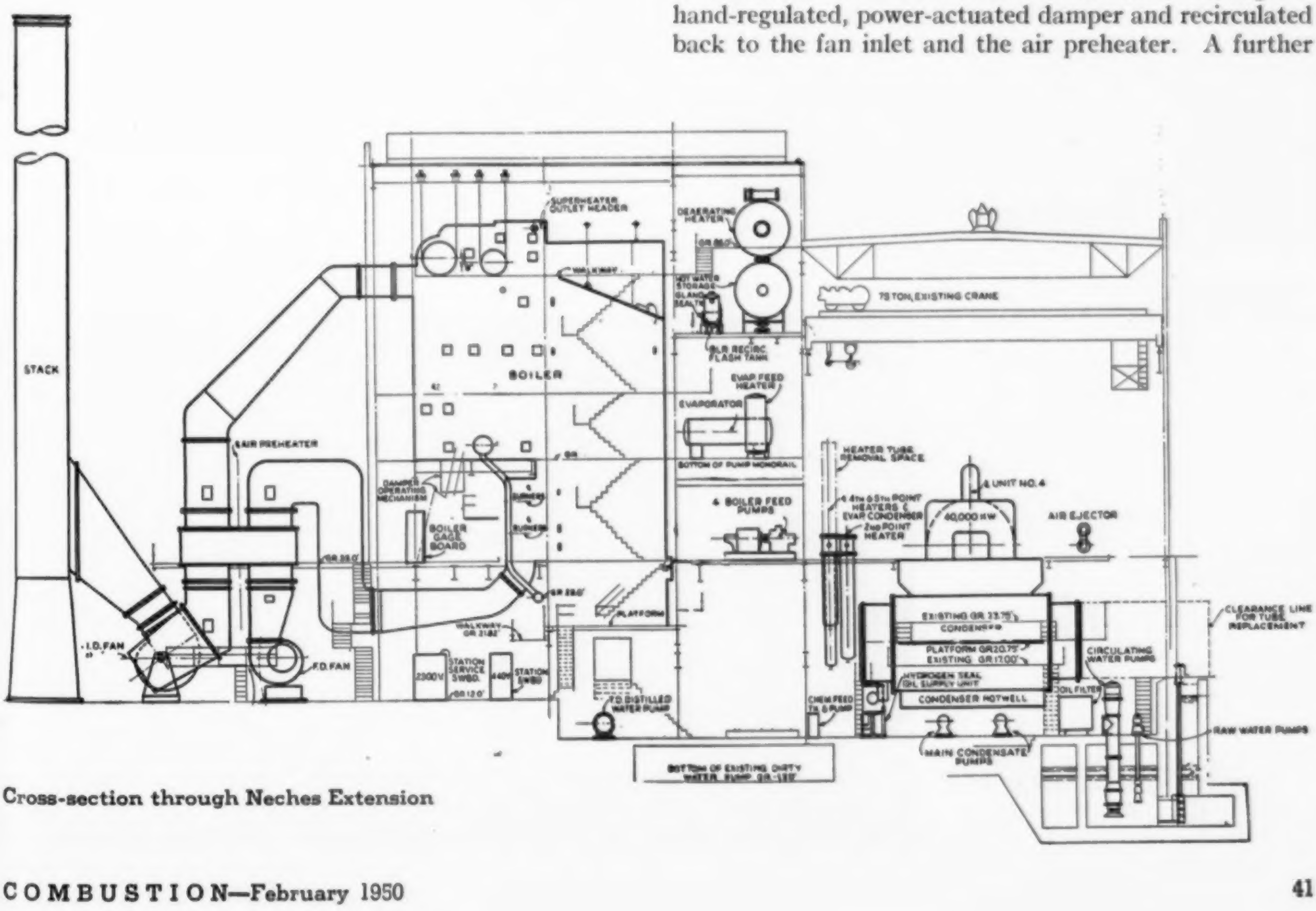
Capability of the steam generating unit when burning natural gas is 400,000 lb per hr continuous, or 440,000 lb per hr for four hours when operating with respective feedwater temperatures of 260 and 372 F. With 10 per cent excess air in the furnace, the overall efficiency is 81 per cent.



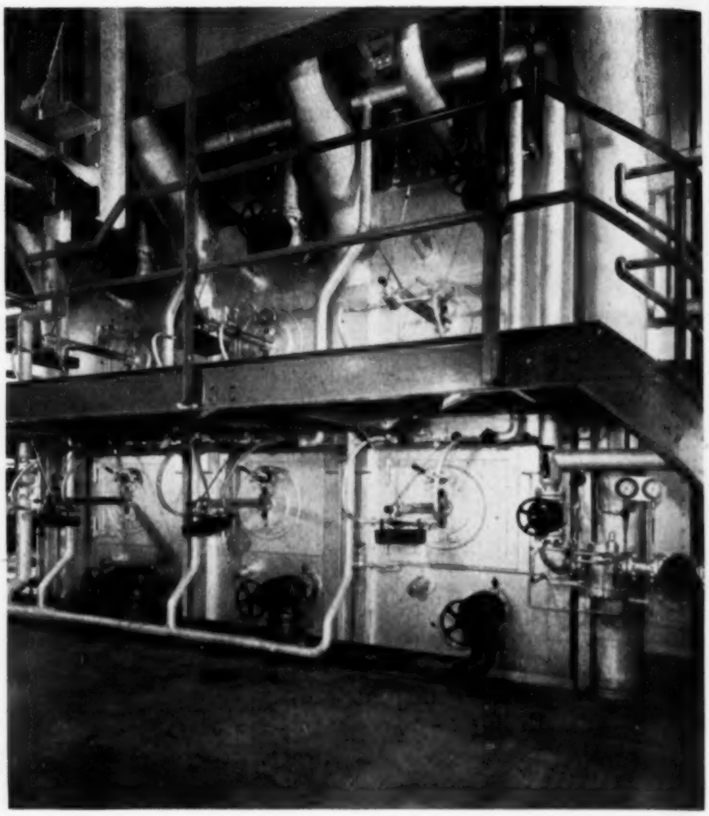
400,000-lb per hr steam generating unit

There are one forced-draft fan and one induced-draft fan, separately driven by constant-speed motors and provided with adjustable inlet vanes. The motors have heaters to prevent condensation during nonoperating periods. At the full rated load of 400,000 lb per hr the flue gas passing through the fan is at a temperature of about 360 F.

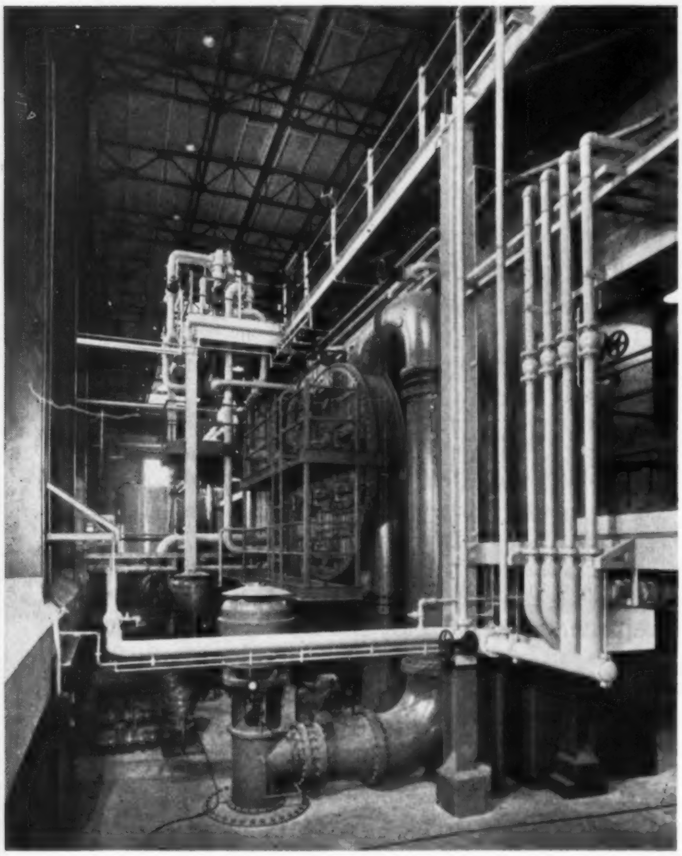
To avoid corrosion in the air preheater some hot air is extracted from the forced-draft duct, through a hand-regulated, power-actuated damper and recirculated back to the fan inlet and the air preheater. A further



Cross-section through Neches Extension



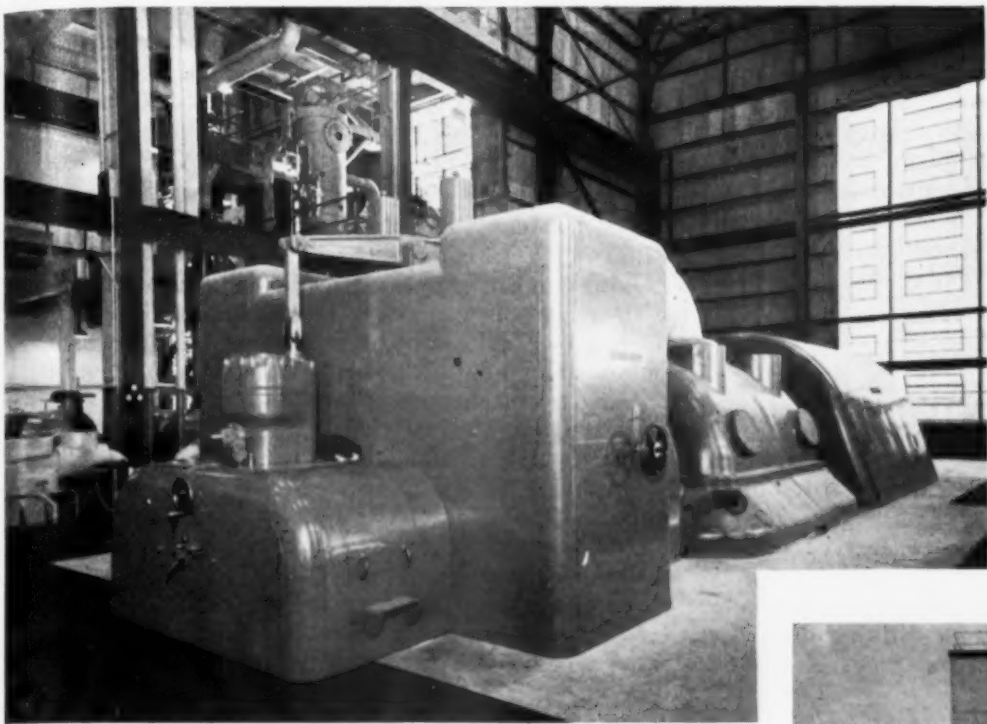
Steam generating unit, showing burner front



Condenser bay with circulating pumps

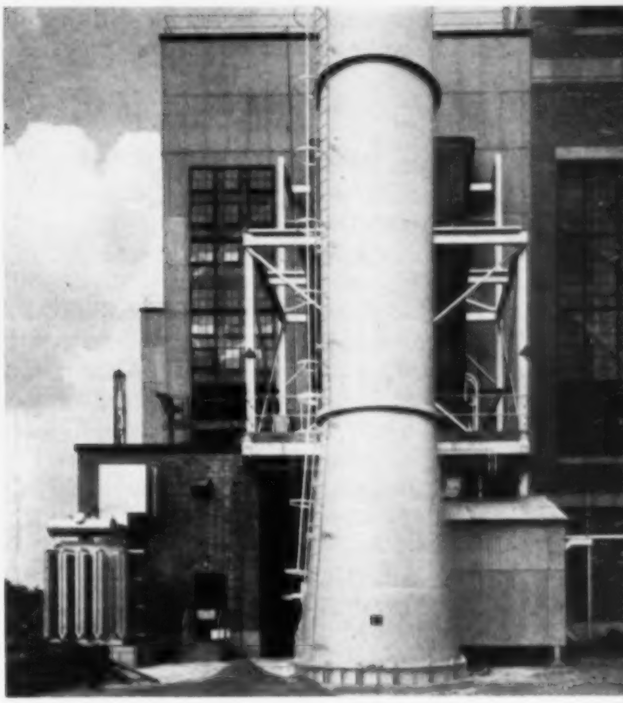
Random Views in the Neches Extension

Boiler feed pumps (turbine-driven pump in foreground)



Turbine-generator No. 4 of 40,000 kw preferred standard rating

Boiler and feed pump control board



Stack and fans serving the extension

Closed feedwater heaters and evaporator-condenser

precaution against corrosion was to make the lower plates of the air preheater of low-carbon, low-chrome or nickel-alloy steel. The rotative soot blower on the air preheater employs saturated steam taken from the boiler drum through a valve that is under remote control.

Safety interlocks are provided to maintain automatically the following sequence of auxiliaries for the boiler: (1) induced-draft fan; (2) forced-draft fan; (3) boiler purge; (4) open gas and/or fuel-oil valve. The last-mentioned operates on loss of gas or fuel-oil pressure and loss of draft.

Turbine-Generator

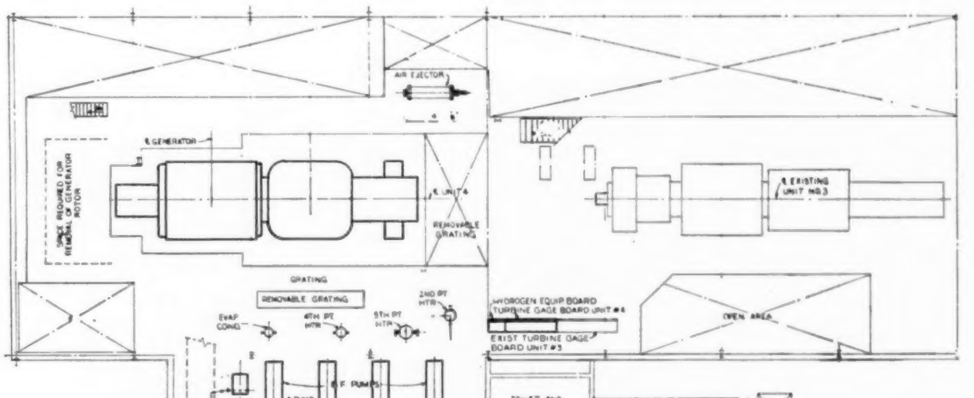
The turbine-generator is a Westinghouse A.I.E.E.-A.S.M.E. Preferred Standards, 40,000-kw, 3-phase, 60-cycle, 3600-rpm condensing unit; the turbine being of the tandem-compound, double-flow design with four extraction openings and a fifth blanked off. The generator is hydrogen-cooled and has a 155-kw, direct-connected main exciter, as well as a 2.5-kw pilot exciter.

A 40,000-kw Preferred Standards turbine-generator has a rated capability of 44,000 kw with five extraction heaters in service, under steam conditions of 850 psi, 900 F and 2.5 in. Hg absolute exhaust pressure. However, in the case of this unit with the top extraction point blanked off, the rated capability under the above steam and back-pressure conditions becomes 45,760 kw. At 1.5 in. Hg this figure becomes 46,950 kw.

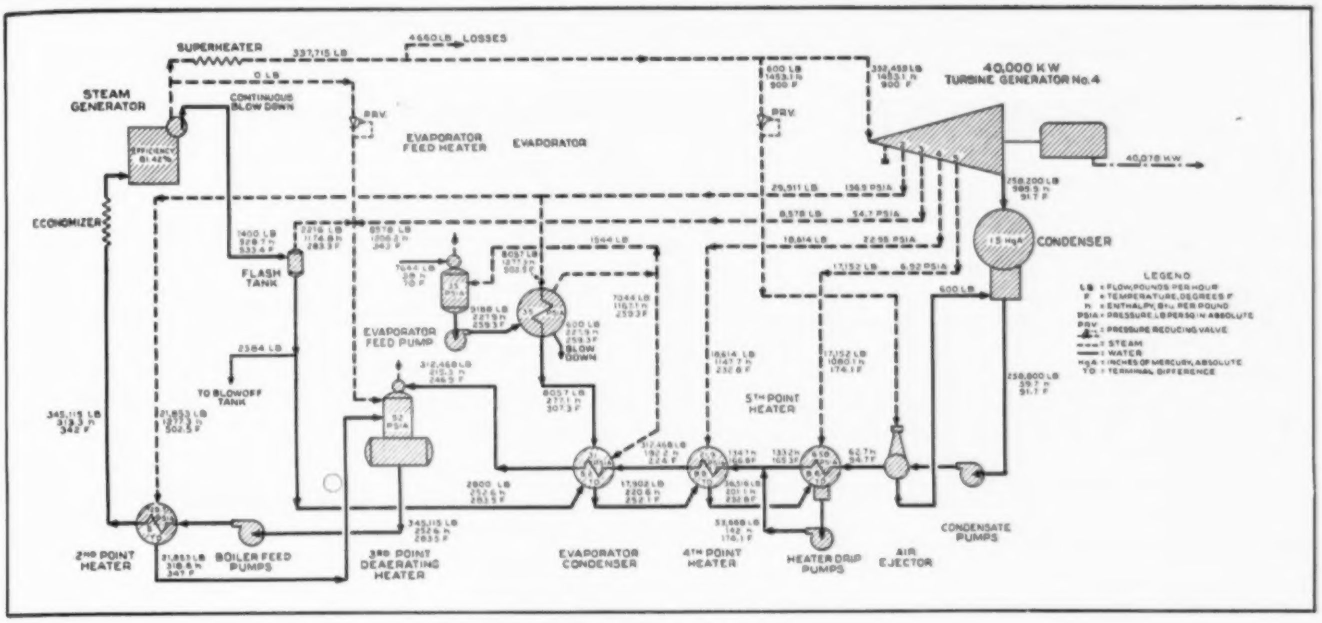
Auxiliaries

The condenser is a horizontal, two-pass design of 37,500 sq ft surface having the circulating-water side divided into halves by a vertical plate in each water box with each half connected to one circulating pump. Thus, either half can be operated while the other half is out, or one pump can be made to serve both halves by opening a butterfly valve in the division plate. This permits a saving in power while using all the tubes when the water is cold or a light load is being carried. When so operating, water is prevented from being forced back into the idle pump by a butterfly valve electrically interlocked with the pump motor and open only when the motor is energized.

A steam priming jet is employed at starting to establish the siphon on the circulating-water side as the water flow through the condenser is from top to bottom



Arrangement of extension with reference to existing units



Heat balance diagram

Station heat rate 11,845 Btu per kwhr; steam rate (gen. basis) 8.3 lb per kwhr

and may leave air entrapped in the water spaces. In regular operation the noncondensible gases are taken out at the top of the condenser, as the coolest water for condensing the residual vapors in the gases is at the top.

The two circulating pumps are of the vertical propeller type, each rated at 16,300 gpm with a total dynamic head of 29 ft. They are driven by 150-hp, 700-rpm, 2300-volt, constant-speed motors and are located in the turbine-room basement. The impellers are of bronze to withstand attack by corrosive water at such times as tidal water backs up to the vicinity of the plant.

Two motor-driven, two-stage pumps handle condensate from the condenser hotwell and discharge, through the inter- and after-condenser, stage heaters and evaporator-condenser to the deaerating heater. The motors are controlled from the condenser control board.

There are four boiler feed pumps, each of 250,000 lb per hr capacity Three of these are driven at 3560 rpm by 500-hp constant-speed motors and the fourth by a steam turbine. Two motor-driven pumps normally supply the boiler and the third serves as standby. The turbine-driven pump insures a supply of boiler feed in the event of failure of the motor-driven pumps, by means of a pressure switch actuated by low boiler feedwater discharge line pressure. An alarm light on the boiler control indicates operation of this pump and an audible alarm is also sounded. They are all located at the boiler operating level with their controls on the boiler control board, thus placing them under the direct supervision of the boiler operator. Overheating of the pumps under reduced flow is prevented by automatically bypassing enough water through muffle-type orifices in the bypass connection from the pump discharge to the deaerating heater. A Bailey three-element feedwater regulating system is provided.

Feedwater is treated with caustic soda to maintain the desired alkalinity, and Hagan phosphate and sodium sulfate are used as corrosion and embrittlement inhibitors. With a boiler water pH of approximately 10.8 a feedwater pH of 8 to 8.5 is aimed at by the continuous introduction of sufficient boiler water to maintain this value. The recirculated boiler water is introduced into the shell of the evaporator-condenser; and after cascading with the evaporated makeup into the shells of the two lower extraction heaters, it is pumped into the condensate line to the deaerating heater, thence to the boiler. This procedure is aimed at protecting the piping and the economizer from corrosion.

The number and arrangement of feedwater heaters is indicated on the heat balance diagram.

Makeup water comes from the Beaumont city supply and is evaporated by a single-effect evaporator capable of handling $2^1/_2$ per cent makeup at full load. This is much more than the usual makeup requirements of a modern central station, but is considered necessary to meet emergencies requiring increased boiler blowdown.

Before entering the evaporator the makeup is preheated and degasified. The evaporator-condenser is designed so as to permit atmospheric venting of gases by means of a shrouded vent, intended to prevent loss of vapor while permitting free discharge of CO_2 and other noncondensible gases.

All the station auxiliaries are motor-driven except the emergency boiler-feed pump and the distilled-water pump, which would be used in an emergency to protect the supply of boiler feed. These pumps must start cold from rest and attain full speed and output in 60 seconds for the former and 30 seconds for the latter.

Electrical System

The main generator feeds directly through its own transformer bank to the 69-kv and 138-kv buses and all synchronizing is done on the high-tension side of the transformers. The station system operates at 2400 and 480 volts through 13,800/2400-volt and 2400/480-volt transformers.

Engineering and construction of the extension was done by Stone & Webster Engineering Corp., Boston, Mass.

PRINCIPAL EQUIPMENT—UNIT NO. 4, NECHES POWER STATION, GULF STATES UTILITIES COMPANY

TURBINE-GENERATOR EQUIPMENT

Turbine-Generator (1)

Westinghouse Electric Corp., 40,000-kw Preferred Standard 850-psi, 900-F throttle steam, 1.5 in. Hg abs exhaust, five bleed points (first point blanked) 3600 rpm, 13,800 volts, 3 phase, 60 cycles hydrogen-cooled with main and pilot exciters.

Condenser (1)

Allis-Chalmers Mfg. Co., 37,500 sq ft, two passes divided water box.

Condenser Tubing *Bridgeport Brass Co.*—(Admiralty $^7/_8$ in. diam × 18 BWG × 26 ft $3^1/_{16}$ in.)

Circulating-Water Pumps (2)

Allis-Chalmers Mfg. Co., 16,300 gpm, 29-ft tdh, vertical, driven by 150-hp, 700-rpm motors.

Condensate Pumps (2)

Allis-Chalmers Mfg. Co., 775 gpm, 440-ft tdh, driven by 150-hp, 1750-rpm motors.

Twin Two-Stage Steam Jet Air Ejector—*Allis-Chalmers Mfg. Co.*
Oil Filter—*Bowser, Inc.*

STEAM GENERATING EQUIPMENT

Boiler (1)

Combustion Engineering-Superheater, Inc., 3 drums, 400,000 lb per hr, 875 psig and 910 F at superheater outlet; 5560 sq ft water-wall surface, 7225 sq ft boiler surface, 18,000 cu ft furnace volume; 29,800 Btu per hr per cu ft heat release.

Economizer

Combustion Engineering-Superheater, Inc. Elesco fin tube, 13,100 sq ft effective heating surface.

Superheater

Combustion Engineering-Superheater, Inc. Elesco pendant type, 9450 sq ft effective heating surface.

Air Preheater

The Air Preheater Corp., Ljungstrom type, 62,400 sq ft.

Fuel

Natural Gas Heating value at 60 F, 30 in. Hg = 1060 Btu per cu ft.

Analysis:

	By Volume
Methane	93.87
Ethane	3.62
Propane	0.93
Butane	0.06
Metrothane	0.94
Hydrogen	0.14
Oxygen	0.01
Argon	0.01
Hydrogen Sulfide	0.01
CO_2	0.41

Forced-Draft Fan (1)

Westinghouse Electric Corp., Sturtevant Division, 135,500 cfm against 14.5-in. H_2O; motor drive, 450 hp, 1180 rpm splashproof with internal heaters.

Induced-Draft Fan (1)

Westinghouse Electric Corp., Sturtevant Division 218,500 cfm against 10.5-in. H_2O; motor drive, 500 hp, 880 rpm splashproof with internal heaters.

Blowoff Valves—*Yarnall-Waring Co.*
Safety Valves—*Manning, Maxwell & Moore, Inc.*
Water Columns—*Diamond Power Specialty Corp.*
Ducts and Breeching—*Missouri Boiler and Sheet Iron Works.*
Steel Stack (9 ft ID × 150 ft high).—*Hammond Iron Works.*

FEEDWATER EQUIPMENT

Boiler Feed Pumps

Ingersoll-Rand Co. Three 540-gpm, 2448-ft head, 3560 rpm, each driven by a 500-hp motor. One 540-gpm, 2448-ft head, 3560 rpm driven by a G. E. steam turbine.

Fifth Extraction Point Closed Heater (29th Stage)

Westinghouse Electric Corp., 875 sq ft, 200 psi gage water, full vacuum to 200 psi gage steam.

Fourth Extraction Point Closed Heater (26th Stage)
Westinghouse Electric Corp., 825 sq ft, 200 psi gage water, full vacuum to 200 psi gage steam.

Evaporator Condenser

Westinghouse Electric Corp., 740 sq ft with gas cooling section, 200 psi gage water, full vacuum to 200 psi gage steam.

Deaerator (22nd Stage)

Worthington Pump and Machinery Corp. Direct contact tray type, 400,000 lb per hr at 52 psi gage.

Evaporator (15th Stage)

Westinghouse Electric Corp., 350 sq ft, 50 psi gage water, 250 psi gage steam, capable of producing 16,000 lb per hr vapor with 120 psi gage steam to coils.

Second Extraction Point Closed Heater (15th Stage)

The Lummus Co., 1362 sq ft, 1300 psi gage water, 200 psi gage steam.

Evaporator Feed Pumps (2)—*Ingersoll-Rand Co.*
Heater Drainers—*Cochrane Corp.*

PIPING VALVES AND INSULATION

High-Pressure Piping Fabricator—*Grinnell Co., Inc.*
High-Pressure Piping Erector—*Grinnell Co., Inc.*
Low and Intermediate Pressure Piping Fabricator—*Southwest Fabricating and Welding Co., Inc.*
Low and Intermediate Pressure Piping Erector—*Stone & Webster Engineering Corp.*
Insulation Contractor—*Otis Massey Co.*
Cast-Steel Valves—*The Wm. Powell Co.*
Forged-Steel Valves—*Edward Valves, Inc., Manning, Maxwell & Moore, Inc.*
Motor-Operated Valve (in main steam line)—*Chapman Valve Mfg. Co.*
Bronze Valves—*Crane Co.*
Cast-Iron Valves—*Jenkins Brothers, Inc.*
Miscellaneous Valves—*Hammel-Dahl Co., Fisher Governor Co., Manning, Maxwell & Moore, Inc., Atwood & Morrill Co.*
Piping Specialties—*Henry Pratt Co., Inc., Joseph Kopperman & Sons, Goodall Rubber Co., Elliott Co., The Parker Appliance Co.*

INSTRUMENTS

Automatic Combustion Control—*Bailey Meter Co.*
Feedwater Control—*Bailey Meter Co.*
Automatic Boiler Feed Recirculation—*Bailey Meter Co.*
Superheater Bypass Control—*Leeds & Northrup Co.*
Temperature Recorders—*Leeds & Northrup Co.*
Conductivity Recorders—*Leeds & Northrup Co.*
CO_2 Recorders—*Leeds & Northrup Co.*
Liquid Level Recorders & Indicators—*Bailey Meter Co.*
Flow Recorders and Indicators—*Bailey Meter Co.*
Pressure Gages—*Manning, Maxwell & Moore, Inc.*
Thermometers—*Manning, Maxwell & Moore, Inc.*
Instrument Control Panels—*G & N Engineering Co.*
Electrical Control Boards—*G & N Engineering Co.*

ELECTRICAL EQUIPMENT

Main Power Transformers (3)

Westinghouse Electric Corp. Single-phase 16,667 kva oil-immersed, self-cooled type, 22,222 kva with fans, 3 winding 13,800 volts delta/69,000/138,000 wye.

Unit Station Service Transformer (1)

Allis-Chalmers Mfg. Co. Three-phase 3000-kva oil-immersed, self-cooled outdoor-type with inert gas equipment. 13,200 volts delta/2400 volts delta.

Reserve Station Service Transformer (1)

Allis-Chalmers Mfg. Co. Three-phase 5000-kva oil-immersed, self-cooled outdoor type with inert gas equipment. 13,200 volts delta/2400 volts delta.

69-Kv Oil Circuit-Breakers (2)—*Westinghouse Electric Corp.*
138-Kv Oil Circuit-Breakers (2)—*Westinghouse Electric Corp.*
13.8-Kv Oil Circuit-Breaker (1)—*Westinghouse Electric Corp.*
Disconnecting Switches—*Delta-Star Electric Co.*
2400-Volt Metalclad Station Auxiliary Switchgear—*Allis-Chalmers Mfg. Co.*
480-Volt Station Service Switchgear—*General Electric Co.*
Motors—*General Electric Co., Westinghouse Electric Corp.*
440-Volt Motor Control—*Square D Co.*
Lighting Panels—*Graybar Electric Co., Inc.*
15-Kv Cable—*The Okonite Co.*
5-Kv Cable—*The Okonite Co.*
Control Cable—*The Okonite Co., American Steel & Wire Co.*
Generator Neutral Breaker—*General Electric Co.*
Meters and Instruments—*Westinghouse Electric Corp.*
Load Frequency Control—*Leeds & Northrup Co.*
Cable Terminators—*Delta-Star Electric Co.*
Bus Supports—*Lapp Insulator Co.*
2400-Volt Metalclad Bus—*Westinghouse Electric Corp.*
Substation Structures—*Bethlehem Steel Co.*

MISCELLANEOUS EQUIPMENT

Tanks—*Wyatt Metal & Boiler Works, John Dollinger, Jr., Inc.*
Air Compressors—*Worthington Pump & Machinery Corp.*
Chlorination Equipment—*Wallace & Tiernan Products Inc.*
Pumps—*Worthington Pump & Machinery Corp., Quimby Pump Co., Ingersoll Rand Co.*

DESIGN AND CONSTRUCTION

Design and Construction—*Stone & Webster Engineering Corp.*

New Water Treating System Produces CO_2-Free Steam—I

By LEO F. COLLINS* and ERNEST E. DUBRY†

This is a description of a zeolite-acid degasification system of special design, laid out by Detroit Edision engineers, which is installed at the Company's Willis Avenue Heating Plant, and which treats the feedwater to rid it of CO_2 held in chemical bondage as carbonate salts, as well as that present as a gas. Because of its length, the article is being continued to the March issue, in which operating experiences and results will be given.

In 1939 it was shown that dissolved CO_2 accelerates corrosion of steam condensing equipment fabricated from the more common metals (1).[1] In 1944 it was shown that even small concentrations will produce failures if large amounts of condensate are flowing (2). In 1945 it was revealed that in most instances the conditions under which condensates are produced are adequate to force a high percentage of the CO_2, entrained by a steam supply, into solution in the contacting condensate (3).

Assuming these findings are valid, it follows that if such troubles are to be avoided, materials immune to carbonic acid[2] attack must be used, or methods devised to prevent the formation of carbonic acid solutions. The latter can be guaranteed either by purging the gas before solution occurs or by treating the steam chemically to neutralize the carbonic acid that otherwise will form.

Studies designed to reveal the possibilities of venting CO_2 from the vapor space of steam condensing equipment, thus proportionately decreasing the amounts available for solution, have shown that such an expedient cannot be depended upon to effect complete elimination and is usable only in limited instances (4). Those metals shown by tests (5) to be virtually immune to carbonic acid attack are too costly for general use and their limited use merely transfers attack down stream to more vulnerable materials. The use of ammonia (6) as a neutralizing chemical is always fraught with the possibility that high concentrations will be built up at unpredictable locations and deteriorate copper and brass parts (7, 8). Studies involving certain of the amines[3] (9, 10) attest that, in industrial plants, where deaeration of the feedwater is employed, their use is likely to prove prohibitively expensive. Where steam is brought into direct contact with foods and the like, the use of certain of the amines would appear inprudent because of their reputed toxicity (11). Stress-corrosion cracking of brass in moist atmospheres containing ammonia or amines has been reported (12).

From this review it is clear that insofar as the control of CO_2-induced corrosion is concerned, the gamut of possibilities has been well investigated with but one exception. The exception involves the possibilities of treating the boiler feedwater to the exclusion of the CO_2 held in chemical bondage (i.e., as carbonate salts) as well as that present as a gas, thus assuring the production of a CO_2-free steam.

For some years this possibility has been given almost continuous study in the Central Heating Department of The Detroit Edison Company. In the fall of 1946 a system of treatment was put into operation at the Willis Avenue heating plant, designed, it was hoped, to produce the desired results. Experience has since shown that this system consistently produces, from carbonate-bearing water only, steam containing such small amounts of CO_2 and oxygen, that neither can be measured accurately with the most exacting analytical techniques known. Thus, for practical purposes, it is felt that such a steam may be considered as CO_2-free.

Inasmuch as power engineers, generally, have been inclined to regard the contamination of steam by CO_2 as almost unavoidable, and because the system in question incorporates a few innovations which yield results heretofore popularly regarded as commercially unattainable, it was thought that a factual description of the development would be welcomed. This paper attempts to supply such a description.

TABLE 1—CLASSES OF BUILDINGS SERVED AND RADIATOR SURFACE INVOLVED

Classes of Buildings Served	Radiator Surfaces,* M Sq Ft/Class
Educational, Medical, and Religious Centers	614
Retail Establishments	572
Residence Lofts (Hotels & Equivalents)	253
Office Lofts	177
Light Manufacturing (space heating only)	140
Entertainment Centers	83
Miscellaneous	50
Total	1889

* Equivalent direct radiator surface to nearest 100 sq ft.

General Considerations

The plant mentioned, one of the Company's four steam heating plants, is located upon the fringe of Detroit's commercial district and adjacent to an area sometimes

* Chemical Engineer, The Detroit Edison Company.
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[1] Numbers in parentheses apply to the literature references cited at the end of this report.
[2] When CO_2 is dissolved in otherwise pure water a carbonic acid solution is produced.
[3] The term amine is applied to an organic material which may be regarded as derived from ammonia by exchange of hydrogen for alkyl-radicals.

referred to locally as the "cultural center" of the city. In Table 1 are shown the classes of buildings served, plus the square feet of equivalent direct radiation included in each class.

Steam is generated at 125 to 135 psig in boilers of the Stirling type fired with underfeed stokers, and the plant is equipped to send out up to 628,000 lb[4] of steam per hour continuously. Fig. 1 indicates the nature of the steam demand upon a cold winter day.

TABLE 2—ANALYTICAL DATA ATTESTING CHARACTERISTICS OF DETROIT CITY WATER SUPPLY

All values are ppm except pH

	Average Normal Condition	After Heavy Rains	Protracted Dry Spell
Metals—Ions			
Calcium—Ca	25	25	25
Magnesium—Mg	6	6	6
Sodium—Na	5	5	5
Silica—SiO	1	1	1
Oxides—Fe_2O_3 and Al_2O_3	1	1	1
Non-Metals—Ions			
Bicarbonate—HCO_3	98	80	120
Carbonate—CO_3	0	0	0
Hydroxide—OH	0	0	0
Phosphate—PO_4	0	0	0
Sulfate—SO_4	21	40	14
Chloride—Cl	6	6	8
Gases and Calculated Values			
Dissolved Solids	163	164	180
Hardness as $CaCO_3$	89	95	80
Free CO_2	2	8	1
Dissolved Oxygen	13	13	13
pH Value	7.1	6.8	7.7

Steam is distributed through a network of underground lines. Because of the sprawling nature of the steam distribution system, and the costs that would be involved in providing and maintaining condensate return lines, it has always been regarded as uneconomical to attempt to provide a condensate recovery system. All the water supplied to the boilers is taken from the municipal supply. Indexes of the mineral characteristics and variations of this supply are given in Table 2.

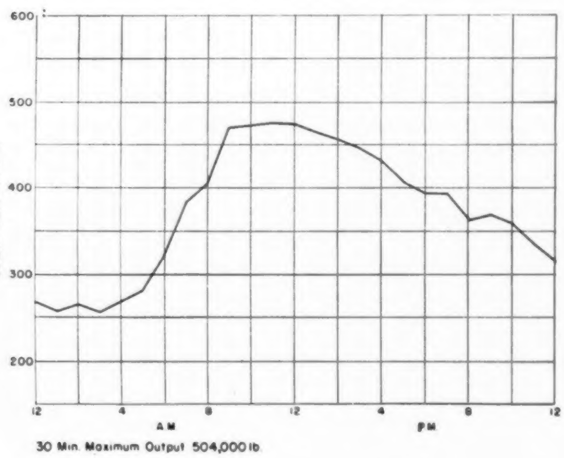

Fig. 1—Output on a cold day

Such water, if used *without treatment* in boilers of the type indicated, will produce about 80 lb of scale per million pounds of water, and the steam derived therefrom will contain 8 to 13 ppm[5] of oxygen and 65 to 90 ppm of CO_2. In plant operation such quantities of scale cannot be tolerated, and such concentrations of deleterious gases would be expected to generate unsufferable corrosion in steam-utilizing equipment.

Original Feedwater Treating System

When the plant was first put into operation, in 1916, industrial water technology, as it is known today, was virtually non-existent. It was generally believed that preboiler softening, thus decreasing proportionately the quantity of insoluble solids formed within boilers, was virtually all that could be accomplished. Accordingly, only an elementary water-treating system was provided. It was arranged as sketched in Fig. 2.

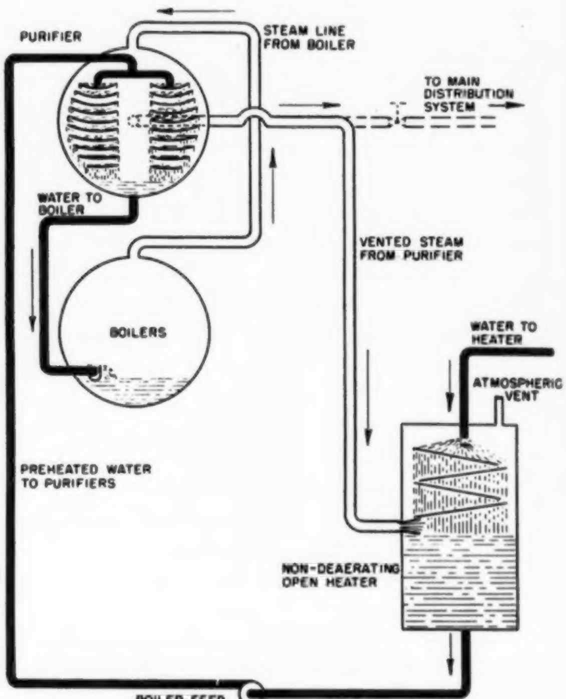

Fig. 2—Essentials of original feedwater system

The purifiers were operated at boiler pressure and the steam vented therefrom comprised a fraction of the plant output. The function of the pans (over which the water cascaded) was to catch the materials precipitated as a result of heating the water. That they fulfilled this function, at least in part, is indicated by the photograph in Fig. 3. Periodically, the pans were removed and the deposits chiseled from their surfaces. The records indicate that about two tons of cement-like deposits were customarily cached by one purifier in one heating season.[6]

Subsequent to Hall's publications, detailing the techniques necessary to the prevention of anhydrite ($CaSO_4$) scale, by maintenance of a minimum (CO_3) concentration in boiler water (13), provisions were made to proportion (roughly) a solution of soda ash (Na_2CO_3) to the open feedwater heater.

[4] Does not include the largest boiler which is held as a spare.
[5] Ppm is an abbreviation for parts per million. One ppm signifies 1 lb of material dissolved in 1,000,000 lb of the solution.

[6] One purifier was provided for each 6000 sq ft (approximately) of boiler evaporative surface.

It was soon discovered, however, that feeding an alkali into the open heater caused the formation of prohibitive amounts of scale in the feed lines. Fig. 4 shows a feed line in which the scale loosened and accumulated at the check valve. At about the same time it was being

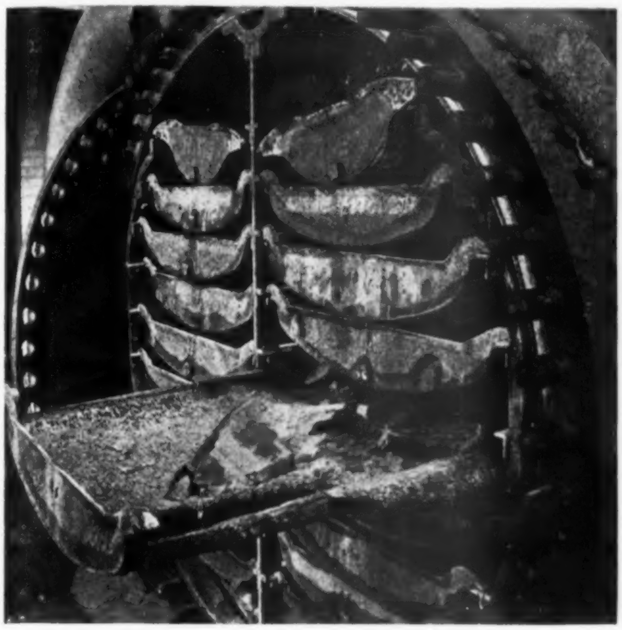

Fig. 3—Scale-laden purifier

"inkled" that CO_2 was a corrosion accelerator in steam heating systems. Because of this rumor and the deposits of feed line scale, it was decided not to allow the purifier vent steam, which was rich in CO_2, to leave the plant. Rather, it was diverted to the feedwater heater. By this expedient the CO_2 in the purifier steam was utilized to prevent the deposition of carbonate scale in the feed lines preceeding the purifiers. To an extent, it also defeated the effectiveness of the purifiers with the results that considerable scale was precipitated directly beneath the water trough in the boilers. Fig. 5 shows such an accumulation. To prevent accumulations of this kind, a maintenance regulation was instituted whereby each boiler was shut down and "desludged," mechanically, after about 3600 lb of steam per square foot of evaporating surface had been produced.

By these several expedients, water conditions generally satisfactory to the operation of the boilers were provided, except for prolonged periods of high steaming rates. However, as the findings, defining the rôle of CO_2 in accelerating corrosion, continued to pyramid, it became more and more evident that the steam which ordinarily contained about 30 ppm[7] of CO_2 was not well suited for use. Thus, in 1940 it was concluded that the acknowledged want was a processing system that would completely eliminate this gas from the boiler feedwater and therefore from the steam produced. War complication held up this development until 1946.

[7] Some CO_2 was purged by the combined action of the purifiers and the open heater. This accounts for the difference between this figure and the total CO_2 content of the city water.

Design of the New Treating System

When the problems of developing the new feedwater treating system were being deliberated, it was agreed that to be acceptable the design would have to meet the following general requirements:

1. Not significantly increase the investment in plant equipment per unit of steam generating capacity.
2. Eliminate the necessity for shutting down boilers solely for desludging.
3. Guarantee scale-free and non-corroded surfaces when boilers are operated at any steaming rate up to the maximum set by the fuel burning capacity of their firing equipment.
4. Not increase the number of men otherwise necessary to the operation of the plant.
5. Not impose upon any shift operator duties requiring more physical effort than those to which such operators had previously been accustomed.
6. Consistently produce steam containing not more than 0.005 ppm of oxygen and 0.5 ppm of CO_2.

To meet the first requirement, it was clear that all the old equipment that could not be made to serve a definite purpose should be junked, and that the new system would have to permit of the operation of boilers at higher steaming capacities than previously had been considered safe.

Experience at two other Company plants (14, 15) showed that a zeolite-acid-degasification system would provide conditions satisfactory to the operation of boilers at the higher steaming rates. It seemed reasonable to suppose that requirements four and five could be met by the more generous use of remote controls and recording meters than is customary in boiler feedwater processing systems.

In meeting the last requirement, experience elsewhere indicated that the limit for dissolved oxygen could be realized by utilizing any of the spray-type deaerating

Fig. 4—Scale accumulated at check valve in boiler feed line

feedwater heaters produced by the more reputable vendors of such equipment. Whether the limits set for CO_2 could be met, however, was a matter of speculation.

Theory indicated two possible techniques for purging the gas. Laboratory findings, however, labeled one as impractical. The reasons are given later in the paragraph devoted to the design of the degasifying feedwater heater.

The diagram, Fig. 6, shows the arrangement of the water treating system finally adopted. This arrange-

ment was selected after careful consideration of four possible variations of the same or comparable equipment. The important reasons for the rejection of the other possibilities are pointed out later.

Fig. 5—Scale-sludge deposit beneath water trough after three months' operation

Softening Equipment

Three zeolite softeners and a wet-storage type brine tank comprise the major water-softening equipment.

The zeolite softeners are constructed as shown by the cross-section view in Fig. 7. They were designed by Company engineers. The treated greensand zeolite was supplied by Hungerford and Terry, Inc.

Up-flow operation at fixed flow rates was selected, rather than down-flow operation, because of the belief that the former assures more uniform softening and better exchange efficiency of the zeolite.

Well screens, in lieu of gravel retaining beds, were selected because they had been found satisfactory in all of our older installations and because they preclude the troubles attendant upon the use of retaining beds (16). Their use, in the case under consideration, was particularly helpful because the tank volume ordinarily taken up by retaining beds was available to receive much of the zeolite. This minimized the overall height of the softeners to conform with the limited headroom available.

Treated greensand was selected because of its satisfactory performance at other Company plants and because laboratory studies (17), involving synthetic resins and treated coals, showed that such products are less durable.

The brine tank, designed by Company engineers, is arranged as shown in Fig. 8. This design was selected because of the limited space available and because of its record of satisfactory performance at another Company plant. A patented type of dissolver, used at a third Company plant, was rejected because experience has failed to show that the brine produced therein yields results superior to those obtained from the type of dissolver selected. Moreover, the frequent cleanings demanded by the patented dissolver waste salt and are an operating nuisance.

Wet storage was selected because it precludes the troubles attendent upon the caking of salt when held in dry storage. Experience had shown that such a nuisance is sometimes encountered even with crushed rock salt.

Acid Equipment

The decision to proportion acid to the effluent from sodium-zeolite softeners rather than to use sodium-zeolite plus hydrogen-zeolite was influenced principally by the following considerations taken in the order given:

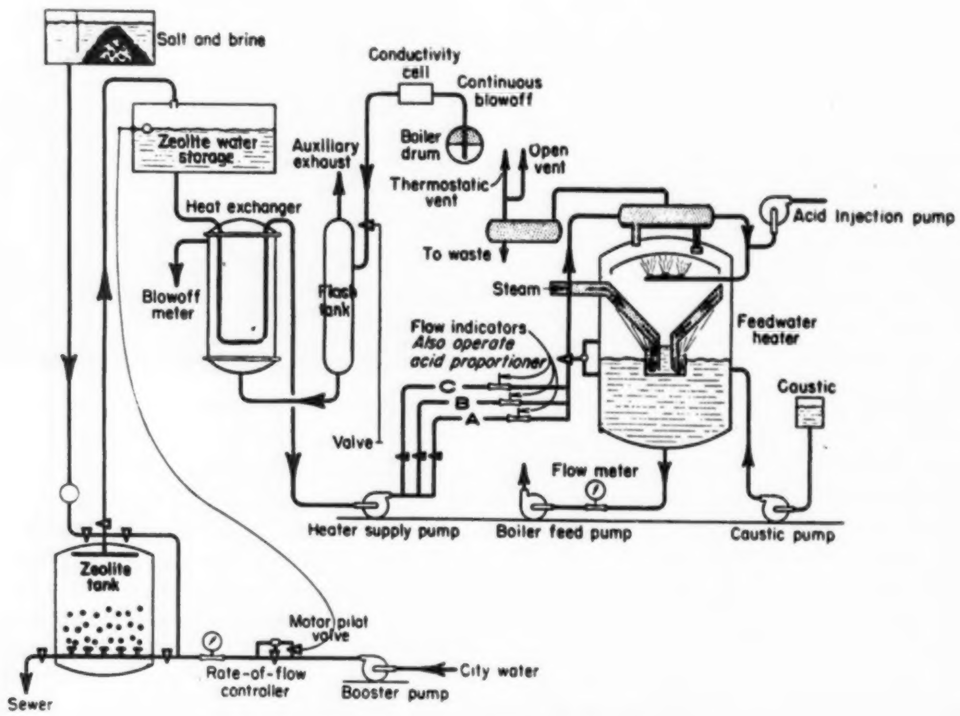

Fig. 6—Diagram of new water-treating system

1. A local ordinance prohibits the introduction of acids, such as are inevitable in the wash water from acid-regenerated softeners, into the city sewers. (Neutralizing tanks were conceived of as a nuisance to be avoided if possible.)
2. An acid effluent, such as can be obtained from regeneration of selected zeolites with a mixture of brine and acid, could not be stored in the steel reservoirs available, and complete removal of CO_2 from an alkaline water was felt to be virtually impossible.
3. The proportioning of acid to sodium-zeolite softened water assures much more efficient use of acid than when it is employed as a regenerant.
4. An acid-proportioning device, designed by Company engineers, was available and had been shown by experience to be both accurate and reliable.

The equipment provided for transporting and storing of concentrated acid, and for mixing of the dilute solution (5 per cent), is identical with that described elsewhere (15). The design of the proportioner, however, incorporates some innovations. The use of an injection pump (to force the effluent of the acid proportioners into the heater influent line) is believed to be unique.

A simplified diagram of the acid proportioning system is shown in Fig. 9. It should be noted that orifices, installed in each of the branches of the manifold of the heater influent line, "trigger" the acid proportioners. The differential pressure created by the flow of water across these orifices is transmitted hydraulically to the mercury pots. The movement of the float, resting upon the surface of the mercury in the inner chamber of the mercury pot, is transmitted via a cable to a counterbalanced arm which supports the acid orifice plus the glass and rubber tubing that conveys dilute acid from the constant level tank to the acid orifice. In this manner the acid orifice is raised or lowered in proportion to the amount of water flowing and its action is almost friction-free.

For reasons obvious to an engineer, the travel of the acid orifice is limited to a range of about 16 inches. Because of this limitation and the wide variations in the amount of water to be treated, calculations indicated it would be virtually impossible to devise a single acid orifice that would dispense *accurately* the required amount of acid to meet all demands. To meet this situation, the manifold was devised. With this arrangement, various sized lines and combinations thereof may be put into operation to meet all plant requirements.

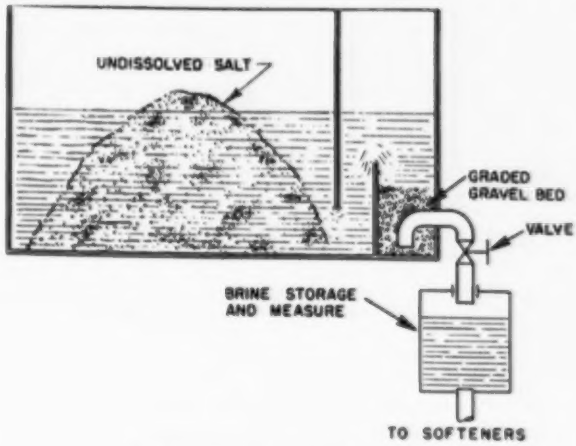

Fig. 8—Wet storage brine tank

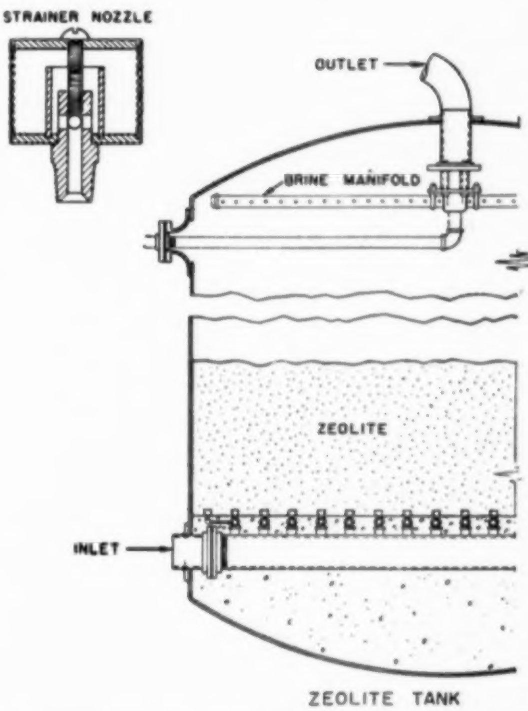

Fig. 7—Cross-section of zeolite softener and nozzle detail

The proportioner is designed to operate upon a volume for volume basis. As such, it cannot compensate automatically for changes in the alkalinity of the water. Fortunately, significant changes in alkalinity seldom occur more than once each 24 hours. A means for compensating, manually, for such changes is provided through use of adjustable acid orifices.

A cross-section of the acid orifice assembly is shown in Fig. 10. By rotating the cone holder, the cone is moved into or out of the acid orifice, and travel of the cone is read from the micrometer-type scale attached. In calibrating these devices a chart was prepared which indicates the approximate setting required for various alkalinities in the water to be treated. This chart is used as an operating criterion.

When the system was first put into operation, no acid injection pumps were provided. It was assumed that sufficient static head had been provided (about 20 ft) to cause the acid, discharged by the proportioners, to flow into the heater influent line. It was soon discovered, however, that despite very close control of heater pressures, variations occurred of sufficient magnitude to annihilate the sensitivity of the acid proportioners. This limitation was satisfactorily overcome by installation of the injection pumps. Two such pumps are provided, to allow for pump maintenance.

Degasifying Heater

When waters of the type corresponding to Detroit's municipal supply are passed through a properly designed and operated sodium-zeolite softener, virtually all of the calcium and magnesium bicarbonates dissolved therein are transformed into chemically equivalent amounts of sodium bicarbonate ($NaHCO_3$). When this is introduced into a steaming boiler, operated at pressures above 100 psig, it disassociates almost instantly, forming caustic soda ($NaOH$) and CO_2 (18). The latter passes off with

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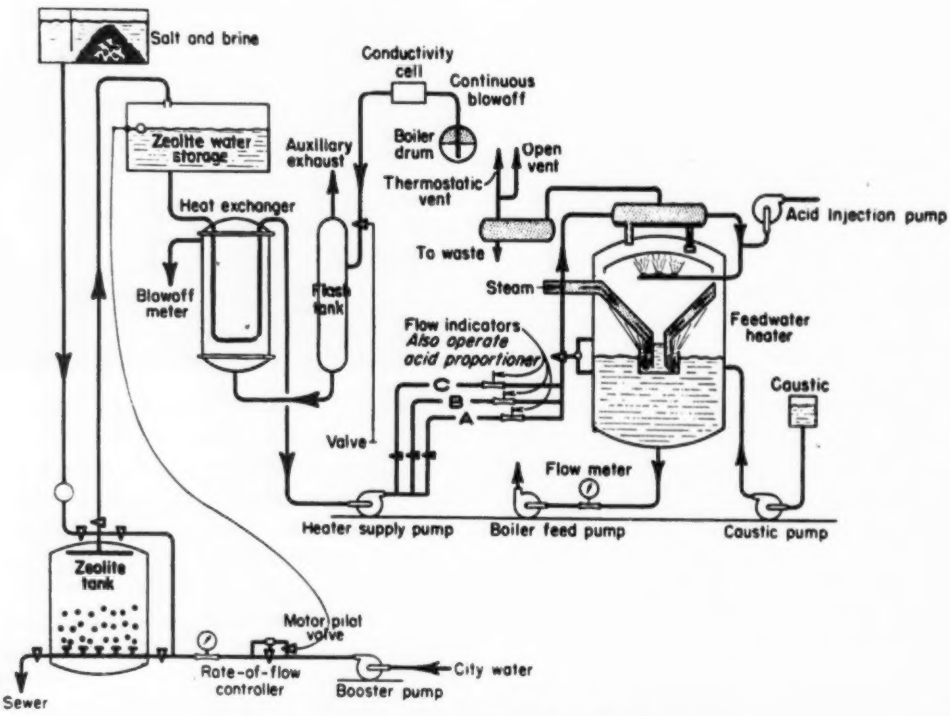

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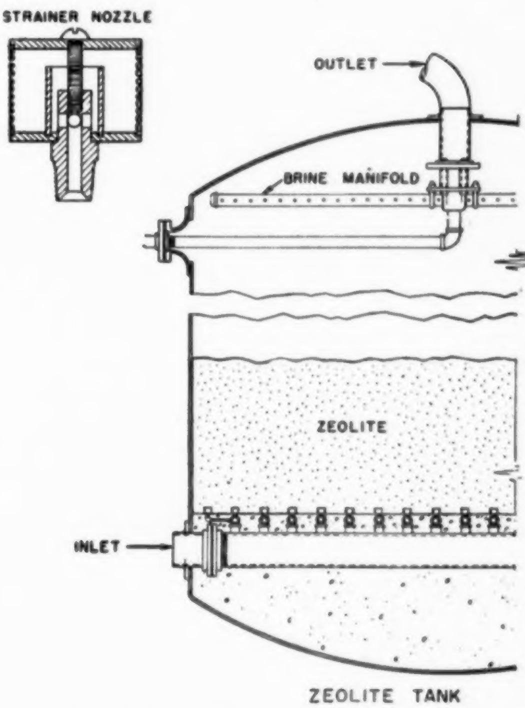

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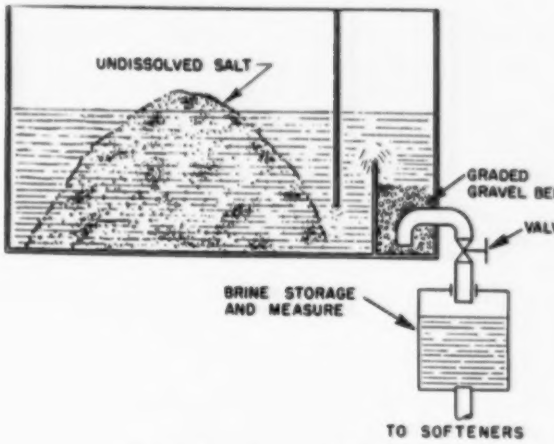

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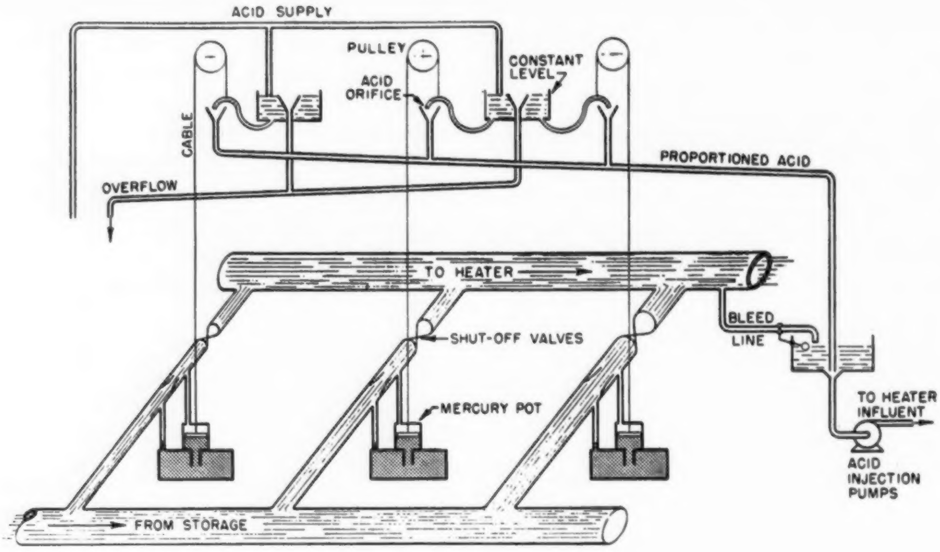

Fig. 9—Acid proportioning equipment

the steam. To produce CO_2-free steam from such a water it is mandatory that *all* sodium bicarbonate be disassociated and the CO_2 purged before the water enters the boiler.

In view of what occurs to sodium bicarbonate in an operating boiler, it could be reasoned that if such a solution were kept at a temperature above the atmospheric boiling point and were violently agitated (as by bubbling through it a CO_2-free gas) the desired results might be obtained. The possibilities of utilizing such a scheme were pursued to the point of requesting bids from the better known vendors of degasifying feedwater heaters, for designing and supplying such equipment. However, none were willing to assume such responsibilities, possibly as laboratory experiments had indicated that impractical amounts of steam and time would be needed (19).

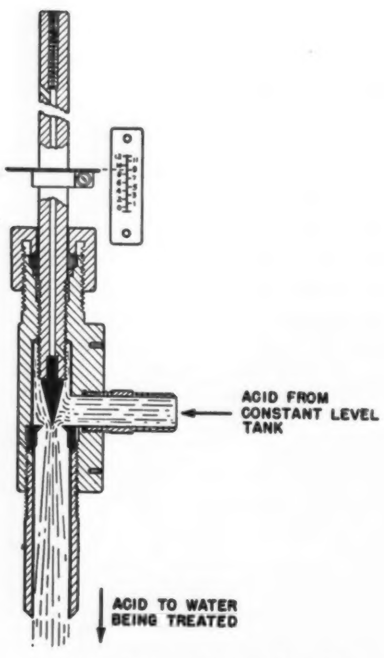

Fig. 10—Adjustable acid orifice

For several years it has been common knowledge that degasifying (more often called deaerating) feedwater heaters of good design can be depended upon to purge from water solutions, almost completely, any gas that does not react chemically with the solution. But even though a dilute solution of $NaHCO_3$ is neutralized as indicated by the equation

$$2NaHCO_3 + H_2SO_4 = Na_2SO_4 + 2CO_2 + 2H_2O$$

not all the CO_2 will be in solution as an inert gas and thus available for removal by schemes predicated upon the

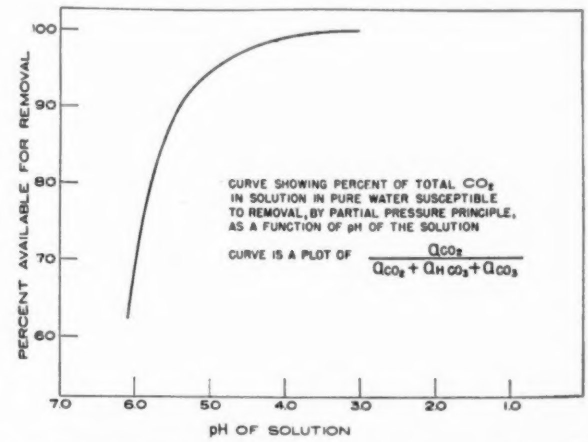

Fig. 11—Per Cent of CO_2 available for removal vs. pH of solution

partial pressure law. A significant fraction will react with the water as conditioned by the temperature and pH of the solution. At room temperature the fraction that does not react, and is therefore susceptible to removal by schemes predicated upon Henry's and Dalton's laws, is indicated by the curve in Fig. 11.

From this curve it was reasoned that if more than enough acid were added to neutralize the bicarbonate in the zeolite softened water, and the resulting acidulated water were passed through a degasifying heater of good

design, operated at about 225 F, the CO_2 should be reduced to a very low value. It was hoped that the latter would not exceed 0.10 ppm, and that simultaneously the oxygen removal would be as complete as normally persists when such equipment is utilized with neutral and alkaline waters.

While it seemed possible that units of conventional design could produce such results, it was certain that, in the fabrication of the unit, common metals could not be used because of the corrosivity of the hot acid water (20). Thus, whether or not the proposed scheme would be practical depended upon the discovery of a metal that could withstand attack under the condition that would be imposed.

heater was not much greater than had a degasifier and conventional deaerator been provided. The heater was designed and built by Worthington Pump and Machinery Corporation.

Equipment for Dissolving and Proportioning Caustic

Since all the steam generating equipment following the heater is of ordinary steel, and of necessity must remain as such, it was mandatory that the water leaving the heater be definitely alkaline. To this end, provisions were made to proportion a 10 per cent caustic solution to the water in the storage space of the heater. Thus, a tank

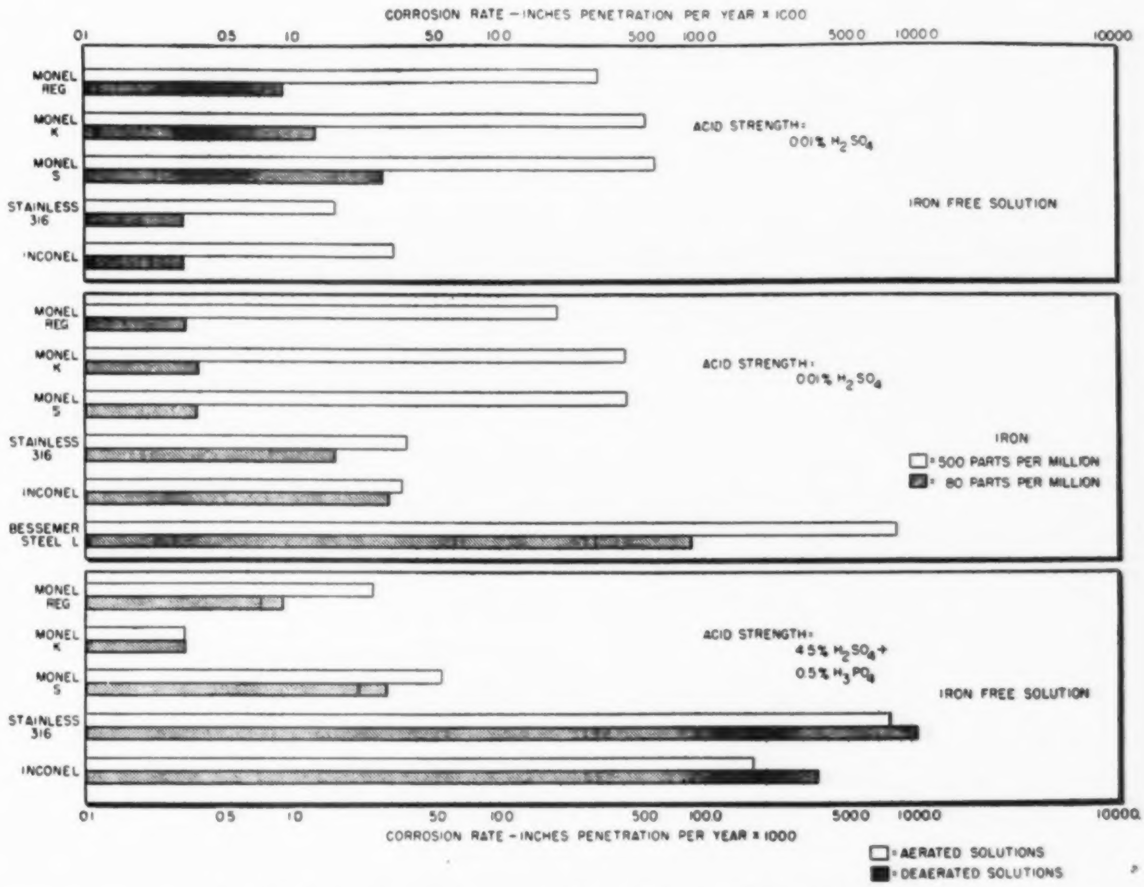

Fig. 12—Corrosion rates measured in boiling dilute acid solutions

When proposals were solicited for such a unit many of the reputable vendors "declined with thanks." All pointed out that no precedents had indicated the metal or other materials to be used. Those making proposals suggested Monel metal, Inconel, or Type 316 stainless steel.

During the period of such negotiations laboratory tests were made, the results of which are shown in Fig. 12. From these data it appeared that stainless steel (Type 316) was the most promising material.

A heater fabricated of the type of metal indicated would be expected to be considerably more costly than a comparable unit of ordinary steel. It should be noted, however, that in the overall design of the system the heater performs the functions usually performed by a degasifier and heater. As a result, the overall cost of the

for preparing the necessary solution, and proportioning pumps were installed.

The solution tank is designed as shown in Fig. 13. Actually, this design superimposes one tank upon another. By this expedient a minimum of floor space is required (a consideration in this instance), but more important, a minimum area of the solution's surface is exposed to the atmosphere. This proportionately slows up the rate of absorption of CO_2 from the contacting air.

The solution is prepared by introducing boiler feedwater (degassed) into the upper tank, and thereafter spilling caustic through the charging hopper.

The proportioning of the solution is accomplished through a motor-driven positive-displacement pump provided by the Milton Roy Company. These pumps,

only one of which is kept in operation, have a micrometer adjustment by means of which the stroke can be changed, manually, while the pump is in operation. Design calculations indicated that such adjustments would ordinarily be required only when the amount of water to be treated varied by more than 50,000 lb per hr. Experience has since confirmed these calculations.

Ordinary steel was used throughout the caustic system. Whenever possible welding was used in lieu of screwed joints.

Instruments and Controls

Major segments of the water-treating system are located on a number of different levels in the plant. Except under peak load conditions, the plant is operated by three men on each shift.[8] In view of these limitations, it was obvious that policing of the system would necessitate much walking and climbing by the operators, unless adequate instruments and remote controls were provided at central locations.

To meet this want, two panel boards are provided upon the operating floor. One, called the "Heater Control Board," supports indicating and recording instruments to measure those physical factors (temperature, pressure,[9]

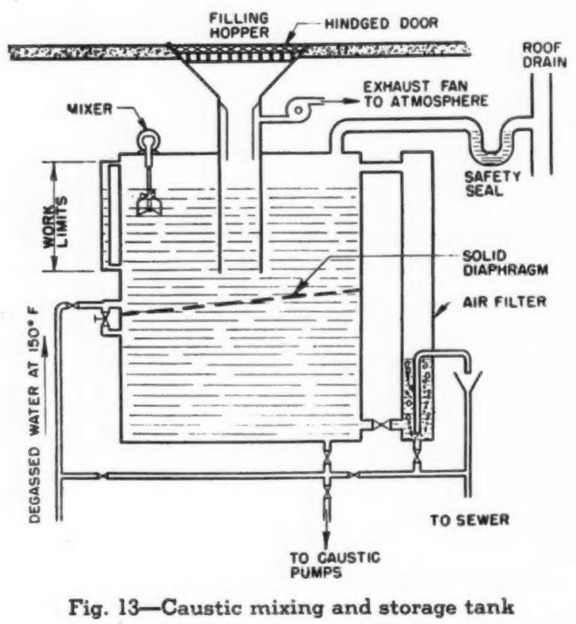

Fig. 13—Caustic mixing and storage tank

water flow) that influence heater performance. At the operating engineer's desk are located remote controls for the zeolite softeners (exclusive of the regeneration operation), and an annunciator which warns (*a*) of the necessity for regeneration of the softeners, (*b*) of low levels in the soft-water reservoirs, and (*c*) the liquid level in the dilute acid tanks. At the same location is provided a three-point recording pH meter, which shows the acidity of the heater influent, the alkalinity of the heater effluent and the CO_2 in the outgoing plant steam. At this same location are provided manually operated valves for regulation of the continuous blowdown from all boilers, and a recording conductivity meter which indicates the total dissolved mineral content of the water in each operating boiler.

The conductivity cells, situated in a bypass of the continuous blowdown line as shown in Fig. 14, are under boiler water temperature. The latter feature eliminates the necessity for cooling the water to some predetermined temperature, which is always a vexing operating task. The pH recorder and cells are Leeds & Northrup Company products. The conductivity meter is a Leeds & Northrup Company product but the conductivity cells are a development of The Detroit Edison Company.

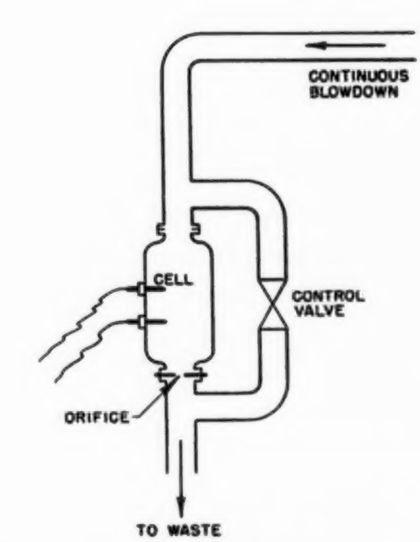

Fig. 14—Method of positioning conductivity cells in blowdown lines

Increment Capital Costs

In most engineering developments capital costs are the consideration that overshadows all others. In the technical literature relating to boiler feedwater processing systems, virtually no information of this character is made available. While most authorities deplore this situation they explain the want as due to the difficulties of presenting such data in their true light.

TABLE 3—CAPITAL COSTS—DOLLARS PER 1000 LB PER HOUR OF SYSTEM CAPACITY*

	Dollars
Water softeners—auxiliaries and reservoirs	75
Acid proportioners and auxiliaries	26
Degasifying heater and supply pumps	88
Caustic mixing and proportioning equipment	12
Continuous blowdown system	4
Instrumentation	20
Miscellaneous	6

* Based upon the designed capacity of feed water heater.

That such contentions are well taken became evident when an effort was made to compile such data for the system under discussion. It was reasoned that a mere tabulation of costs, for major segments, would be of little value because few of those requiring such data would have to contend with the same circumstances and com-

[8] Plant maintenance, the mixing of acid and caustic, and filling of the brine tank are done by other than shift operators.
[9] The steam pressure on the heater is automatically controlled except for large changes in load.

binations thereof as were governing in the present case. Thus, it was reasoned that if the data were to suffice as criteria they would have to be reduced to some basis common to steam generating plants.

In any chemical processing system, comparable to the one in question, the equipment that performs an indispensable function and has a capacity less than that of any other major component defines the maximum rate at which *the system* can be operated. In the present case the degasifying heater is the "throttle." Thus, the installed cost of each of the major segments was divided by the heater capacity. The resultant figures, shown in Table 3, disclose the cost per 1000 lb of system capacity that was involved for each of the major components of the installation.

(*Continued in the March Issue*)

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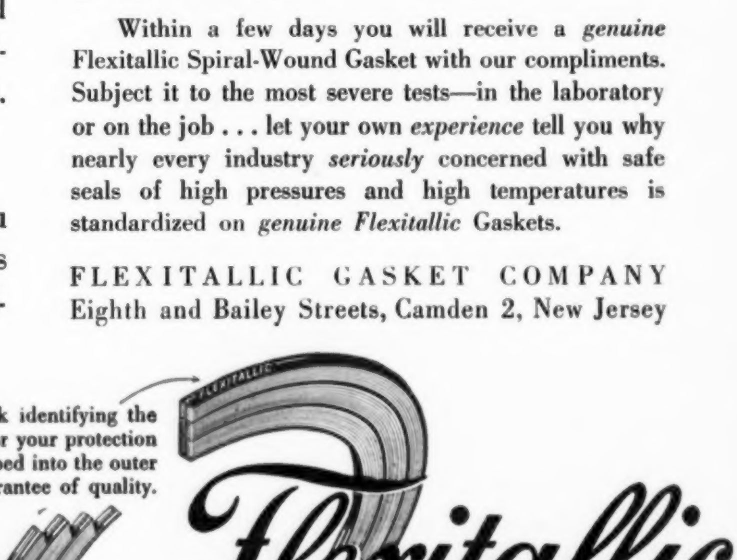

A Suggested Solution to Burning High-Ash Coal

By WILHELM GUMZ, Dr.-Ing.*

Combination of coal gasified in a special type of down-draft gas producer with a gas-fired boiler is suggested for using high-ash or low-grade unwashed coal without incurring furnace slagging or excessive deposits on heating surfaces. This would permit higher heat releases and higher gas velocities and, in the author's opinion, would be adapted to pressure combustion.

DEVELOPMENT of combustion equipment is in a steady flux, changing with both technical improvement and economic necessity. Coal, as the principal source of power in stationary plants, has met keen competition from fuel oil and natural gas, and to reclaim or hold its position new ideas and new possibilities must be considered.

Suitability, availability, and cost of fuel are the essential factors in its selection. Cutting down coal cost means highly mechanized working methods and departure from cost-increasing processes such as cleaning, sizing, pulverizing, etc. If a coal of low production cost, which is consequently a low-grade fuel, is used, two problems must be faced: (1) combustion with efficiency comparable to that of a high-grade, carefully selected coal, and (2) the slagging problem.

The Combustible Matter

Combustion of coal either on a grate or in suspension is a physico-chemical process controlled mainly by physical factors, primarily the mass transfer of oxygen to the surface of the carbon. Depending upon the type of furnace and the coal-feeding methods, the volatile matter is released precedently or simultaneously. The amount of coal burned in a furnace, therefore, is mainly a function of the amount of air brought into contact with the surface of the fuel; and combustion efficiency depends entirely upon the degree of mixing air and fuel, and the time necessary to complete the combustion reaction.

Limiting factors in the rate of burning are influenced by the type of furnace. With mechanical grates and stokers the rate of ignition (underfeed) and the increase of carbon losses by growing instability of the fuel bed (overfeed or crossfeed) are responsible for the final limitation of burning rates. With thick fuel beds the partly or fully devolatilized layer of coal (char) may be considered as a gas producer in which the solid fuel is converted into combustible gas that burns to CO_2 partly within the fuel bed and partly in the furnace space above. To counteract stratification of the gases and to mix the gaseous constituents (the volatile matter as well as unburned gas produced from the fixed carbon) with oxygen, the furnace is engineered as a mixing device by providing front and/or rear arches. Overfire air jets have been successfully applied for this purpose. Hence it would appear that the process of combustion is a combination of devolatilization, gasification, and gas burning, though without a sharp separation of these processes.

In pulverized-coal firing the process is somewhat different. The fuel carried by its combustion air and its combustion products travels concurrently through the furnace, generally requiring a larger furnace volume than a stoker-fired boiler. The time required for rather complete combustion depends upon the fineness of pulverization, the swelling propensity of the fuel, and its volatile matter content. Devolatilization, gasification, and combustion occur in spheres surrounding the individual fuel particle.

The Mineral Matter

There is practically no solid fuel without mineral matter, and maximum combustion rates are closely tied to the behavior of the inorganic substances during combustion. The higher the burning rates, the more serious are the clinkering and slagging troubles, furnace-wall slagging, and deposits on boiler and superheater surfaces.

The principal mineral constituents of coal (notably bituminous coal) are listed in Tables 1 and 2. When these pass through the high-temperature zone a great variety of reactions take place; kaolinite and sulfates are dehydrated; carbonates are deacidified; oxides and sulfides are roasted or reduced by the presence of carbon; carbon monoxide and hydrogen act as reducing agents; and finally, the ash constituents are sintered, partly molten, and converted into slag. Most significant is the part played by the sulfur and its reaction with the inorganic substances to form sulfides. One of the most troublesome reaction products is the silicon sulfide (SiS and SiS_2); because under the temperature conditions of the furnace both are vapors never caught by any gas-cleaning device or filter. They serve as a carrier to transport silicon through the boiler system. By sublimation on the water-or steam-cooled surfaces the silicon sulfides, now of a sticky nature, are held back and pro-

* At present associated with Battelle Memorial Institute, Columbus, O.

mote adherence of fly-ash particles. By oxidizing action of the flue gas (containing excess oxygen) the sulfides are converted to SiO_2. This is found generally to form the inner layer of slag incrustations on boiler tubes, discernible as a white powder.

TABLE I—MINERALS OCCURRING IN BITUMINOUS COAL ASH (After Mackowsky (1))

Mineral	Chemical Composition	Mode of Occurrence*
Topaz	$Al_2F_2SiO_4$	(7)
Zircon	$ZrSiO_4$	(6)
Staurolite	$2Al_2SiO_5 \cdot Fe(OH)_2$	(7)
Tourmaline	Alumino-silicate containing boron	(7)
Quartz	SiO_2	(5)
Garnet	$(Ca, Mg, Mn, Fe)\ (AlFe)_2Si_3O_8$	(7)
Epidote	$Ca_2(AlFe)_3OH(SiO_4)_3$	(7)
Rutile	TiO_2	(7)
Pyrite	FeS_2	(2)
Marcasite	FeS_2	(2)
Melnikovite	FeS_2-gel	(2)
Feldspars:		
Orthoclase	$KAlSi_3O_8$	(7)
Albite	$NaAlSi_3O_8$	(7)
Hematite	Fe_2O_3	(4)–(3)
Magnetite	Fe_3O_4	(6)
Augite	$(CaMg)Si_2O_6$	(7)
Hornblende		(7)
Apatite	$Ca_5FSi_2O_6$	(7)
Cyanite	Al_2OSiO_4	(7)
Sphalerite	ZnS	(3)
Magnetic pyrite	FeS	(6)
Siderite	$FeCO_3$	(3)
Ankerite	$(Fe, Mg, Ca)CO_3$	(3)
Dolomite	$MgCO_3 \cdot CaCO_3$	(4)
Barite	$BaSO_4$	(4)
Chalcopyrite	$CuFeS_2$	(4)–(3)
Calcite	$CaCO_3$	(2)
Muskovite	$(KAl_2)(OH,F)_2AlSi_3O_{10}$	(6)
Biotite	$K(MgFe)_3(OH)_2(AlFe)Si_3O_{10}$	(6)
Galena	PbS	(4)–(3)
Kaolinite	$Al_4(OH)_8Si_4O_{10}$	(1)

* Modes of occurrence: (1) = very frequently, (2) = frequently, (3) rather frequently, (4) = rarely, (5) = rather rarely, (6) = very rarely, (7) = extremely rarely.

As oxidation is one possibility of converting the sulfides into neutralized oxides the proper proportioning and distribution of excess air is indispensable not only from the point of view of combustion but also from that of slag control and consequent boiler availability. Whenever no excess oxygen is applicable, as, for example, in gas producers and cupola furnaces using dry air blast, the silicon sulfide formation is excessive and the gas exit ducts are covered with white dust (SiO_2). Fortunately in the presence of steam the sulfides decompose (by hydration). Gas producers using wet blast are practically free from this kind of deposits.

TABLE 2 TYPICAL LIMITS OF CHEMICAL CONSTITUENTS OF COAL ASH (In percent)

	Coals from U. S. A. (2)*	British Coals (3)	Central European Coals (4)	
			Bituminous Coal	German Lignites
SiO_2	20–60	25–50	25–45	8–18
Al_2O_3	10–35	20–40	15–21	4–9
Fe_2O_3	5–35	0–30	20–45	2–6
CaO	1–20	1–10	2–4	25–40
MgO	0.3–4.0	0.5–5	0.5–1	0.5–6
TiO_2	0.5–2.5	0–3	...	...
Na2O and K_2O	1–4	1–6	...	...
SO_3	0.1–12	1–12	4–10	0–50

* See list of references.

In pulverized coal furnaces the mineral matter has two main disadvantages—it limits the maximum temperatures of the gas entering the boiler system, hence the maximum heat release in the furnace, and it creates a more or less serious fly-ash problem.

Thus, in the selection of fuel, mineral matter has turned out to be even more important for power engineers than is the combustible. The tendency to use lower grades of coal with higher ash contents and possibly even more undesirable ash characteristics will aggravate these problems. The wet bottom furnace, the slagging-chamber furnace, and the cyclone burner (5) are some steps that have been taken toward eliminating a major portion of the mineral matter during the process of combustion. The Szikla-Rozinek furnace (6) is another attempt to remove the slag from the combustion zone by subdividing the combustion chamber into sections for the consecutive combustion and gasification (including deslagging), devolatilization, and gas combustion.

A more rational solution of the slag problem would appear to be the complete separation of inorganic and combustible matter outside the furnace. This can be done by gasification of the fuel and combustion of the gas produced. However, the mere combination of a standard gas producer with a conventional gas-fired boiler does not represent an attractive solution of the problem. An effective approach toward a new firing system supposes the possibility of developing a type of gas producer with the following characteristics:

1. Utilization of fine (or run-of-mine) coal, caking or non-caking
2. Independence of ash content
3. Operability with different ash characteristics including low-fusion temperatures
4. Considerable increase in rates of gasification
5. Effective separation of clinker from combustible matter and lowest possible carbon loss in the residues
6. Low exit gas temperature to permit effective gas cleaning by simple means.

Reviewing the different gasification processes, all those would have to be discarded which operate on carefully selected lump fuel and coke or non-caking coal only. Gas producers such as the rotating-grate type with mechanical contrivances to break up the caked fuel bed or combinations with low-temperature carbonization shafts are unable to meet the condition of high ratings. These diversified requirements narrow the choice of equipment but fortunately they can be met completely by the principle of down-draft gasification. This recently developed type of gas producer (7), namely the Flesch-Winkler producer, is characterized by a down-draft gasification in a fixed bed and alternate deslagging by fluidizing the inventory, thus separating the fine combustible matter from the lump slag. Fresh feed is added during the fluidizing period, thus thoroughly mixed with the devolatilized non-caking char. This producer, therefore, can be operated with caking fine coal at rates considerably higher than in up-draft gas producers, using the same size of fuel. Gas exit temperatures are moderate and carryover losses nearly negligible. By further development of this type of gas generator, a close adaptation to the purpose of a boiler furnace—as well as many others; see reference (8)—appears possible.

Burning gas in the boiler furnace only and keeping out all the mineral matter (except perhaps an inevitable very small percentage) involves a complete change in boiler and furnace design.

Starting with the blast in this brief discussion, it is desirable to have moist air because moisture was found to contribute substantially to neutralizing the effect of sulfides as well as temperature control in the oxidation zone of the gas producer. The addition of live steam is undesirable. Waste heat may be employed to saturate the blast, e.g., by preheating the air fairly

high and passing it through a saturator. The saturated air, now at a temperature of about 120 to 140 F may be superheated again in a second air preheater to any desired temperature. Practically, there is no further limitation in maximum air or blast temperatures. This means that low gas exit temperatures are admitted and a large fraction of the total heating surface may be replaced by the relatively cheap air heater surface. High temperature differences are maintained in both these suggested air heaters (before and after the saturator).

The heat release in the gas-fired furnace, unlimited by the presence of inorganic matter or liquid slag droplets, can be increased, also there is the possibility of applying higher furnace pressures. It will be a matter of economic consideration to raise the furnace pressure slightly, or to a higher degree with a gas-tight boiler casing, to eliminate the induced-draft fan and to employ appropriately higher gas velocities. An even more radical step would be to increase the pressure to three to four times atmospheric (as in the well-known Velox boiler), reclaiming the excess power by a gas turbine. Gasification, gas cleaning and feeding a combustor with a relatively clean gas ensures a better protection of the turbine blades from abrasion than in a direct firing system.

For the steam boiler, these measures would reduce space and steel demand substantially. As an immediate consequence of converting the solid fuel in a gas fuel free from ash an increase in boiler availability might be expected as well as higher efficiencies under average operating conditions due to cleaner heating surfaces. The flue dust problem would be solved without an expensive precipitator.

Efficiency would be influenced mainly by the carbon content of the discarded slag. Pilot plant investigations have shown that even with low-grade coal a very low figure of carbon content can be maintained. The most decisive advantage is the possibility of using low-grade fuel without preparation with nearly the same efficiency as premium coals. Although this has still to be substantiated by experimental data there is no doubt that this goal is within reach at the present status of gasification research and development.

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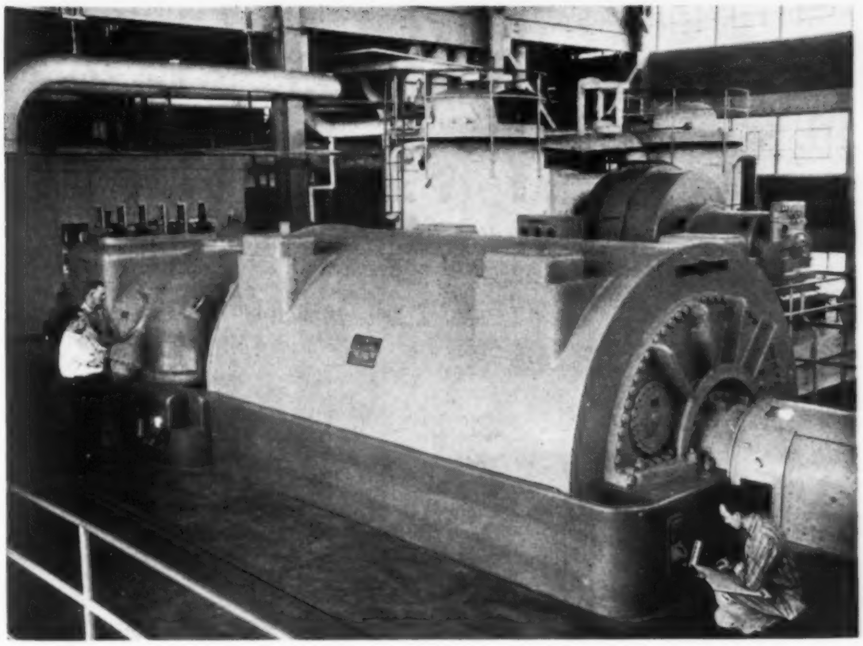


Turbine room of Schiller Station showing 25,000-kw steam-turbine-generator in foreground and one of the mercury turbines, together with the two condenser boilers in the background

Another Mercury-Steam Station Goes Into Service

On January 18, the new Schiller Station of the Public Service Company of New Hampshire, at Porstmouth, was placed in service. Although of only 40,000 kw initial capacity, it is notable in that it contains two 7500-kw General Electric mercury vapor turbines and one 25,000-kw G. E. steam turbine, and its performance is expected to mark a new low in heat consumption for a station of its size; in fact, the estimated overall station heat rate is approximately 9200 Btu per net kilowatt-hour.

In operation the liquid mercury is vaporized in the two mercury boilers, and after passing through the mercury turbines is condensed in the two condenser-boilers where enough latent heat is given up by the mercury vapor to generate the steam to drive the 25,000-kw steam turbine. The mercury conditions are 110 psig, 941 F initial and 2.78 psi abs. exhaust. Steam conditions are 640 psig, 825 F and 1 in. vacuum.

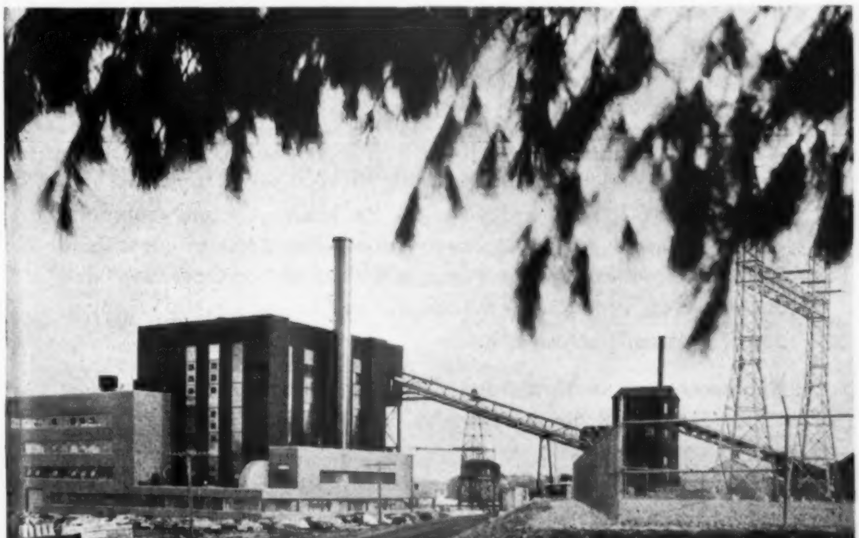
Control and starting of the auxiliary equipment is from a supervisory control room located on the main operating floor, but the three main turbine-generators are started by hand controls at each unit.

The firing equipment is arranged to employ either pulverized coal or fuel oil, the coal-handling system being shown in the accompanying view of the station.

The power house is of welded steel frame construction with brick and prefabricated siding.

In view of experience gained with other mercury-steam installations, leading to the present standardized design, such reliability was anticipated as to preclude a standby steam boiler.

Power from the new station will feed into the company's transmission system, which is served by six other fuel burning plants and 31 hydroelectric plants, and serves about 70 per cent of the state of New Hampshire.



Exterior view of Schiller Station at Portsmouth, N. H.

Some Highlights of A.I.E.E. Winter Meeting

OF more than 250 technical papers and talks at the Winter General Meeting of the American Institute of Electrical Engineers, held at the Hotel Statler in New York, January 30—February 3, there were some that should hold general or specific interest for COMBUSTION readers. Among these were talks at the General Session and a group of papers on centralized control, nuclear power, and hydrogen cooling of generators.

The keynote speaker at the opening General Session, presided over by President J. F. Fairman, was **Harold E. Stassen,** president of the University of Pennsylvania, whose remarks dealt with the world's present economic and social conditions. Speaking of Britain, where he had lately spent considerable time, he cited figures showing that the output of the nationalized coal industry in 1949 had fallen 20 million tons below the 40-year pre-war average under private ownership, despite all-out government efforts to promote increased production. Again, textiles, which are of extreme importance to British economy and export, were only 82 per cent of pre-war production, although special emphasis was placed by the government on recruiting workers for the mills and making the necessary cotton available through establishment of pools.

The overall British production problem, of which these are only two examples, persists despite an increased labor force; but the output per man-hour is less than before the war. This situation Mr. Stassen attributed principally to lack of incentive for productive effort, or some form of penalty for loafing—in other words, failure to take account of human nature. Extremely high tax rates also appeared to be a factor not only in discouraging overtime, but also in promoting absenteeism. In Russia, where incentives for the worker are very limited, some measure of increased production is attained by stepping up the penalties.

However, Mr. Stassen was of the opinion that ultimately the British would find a way to pull out of their present difficulties. Meanwhile, we in America should observe, as a lesson, what Britain is going through.

A second talk, by **Sir Ernest Benn** of London, on "Why Go the Way of Britain?" was presented by transcription. Following are some highlights from this address:

"What the planners have done to currency and monetary exchange illustrates what is happening in Britain to every other commodity and service that crosses national barriers. . . . Socialism is not a system, but a disease, as we English have at long last discovered, and the *something for nothing* mentality is, in fact, an economic cancer.

"Our latest tax returns," he said, "show that there are only 70 persons resident in England with a net spendable income of 6000 pounds, or over."

At this General Session honorary membership in the Society was conferred upon **Dr. Vannevar Bush,** president of Carnegie Institution of Washington and widely recognized scientist and engineer.

Centralized Station Control

B. F. Borgel of the Pennsylvania Electric Company presented a paper entitled "Design and Operation of Central Control Rooms". In it he outlined steps leading to the adoption of the central control system in the Warren steam plant of that system, the design features of the control room, and basic changes which have been found advisable as a result of actual operation. Because of the geographical spread of the system over a mountainous area 300 miles in extent, it is subjected to severe disturbances from electrical storms. Also, several of the generating stations are located in metropolitan or industrial areas where immediate pickup is essential when tie lines are reclosed. For these reasons the need for rapid communication between various operators and the ability to pick up load rapidly have long been recognized as essential.

A control room was therefore designed for the Warren Station to include the following control functions:

(*a*) Operation of boilers, generators and auxiliary power supply.

(b) Indicating and recording supervision of turbines, hydrogen systems and feedwater systems.

(*c*) Annunciator alarms on miscellaneous plant equipment, such as water screens, service pumps, storage tank levels and air compressors.

Plant operation is facilitated by grouping associated equipment and by locating various groups in a functional sequence. Vertical segregation of equipment is followed, and all start-stop stations are in a horizontal line at one level, as are all remote control stations, though on a different level of the panel board. Maximum usage has been made of all available types of handles for control stations, examples being that pistol grip denotes breaker control, while oval grips indicate remote operating controls. Throughout the design a primary objective was to provide a layout to aid the operator to think and follow the correct sequence of operation.

Among the basic changes in the design which have been found desirable are the following:

1. Only those instruments which are required for minute-to-minute operation should be concentrated on the control-board fronts. Application of this principle would shorten by 30 per cent the boards installed at the Warren Station. Unless board fronts are short enough to permit normal coverage by one operator, the major benefit of centralized control may be lost. The use of airplane-type instruments and miniature controls, permitting station monitoring and operation from a single seat, may be a part of the control room of the future.

2. Relocation of the generator hydrogen and indicating panel to a location adjacent to the actual hydrogen equipment may be advisable to assist the operator in adjusting hydrogen supply and to eliminate hydrogen leakage into the control room.

3. Use of pressure transmitting devices with the sender located at the boiler drum or other pressure point and multiple indicating points in control rooms would avoid the dangers and attendant disruptions of a pressure blowout in the control room.

4. Certain advantages may be obtained by arranging the control room to obtain greater plant visibility by the operators and by adjusting lighting so that there is not too much contrast between the control room and the remainder of the plant.

Additional cost of the Warren control room was found to be $1 per kw of nameplate capacity, and it resulted in the elimination of two shift operators, as contrasted to conventional control design, thus providing a continuing return on the additional investment. Further benefits have been realized from faster and more efficient plant operation, and the company is convinced of the economic feasibility of the modified control room, where it is designed to meet a specific purpose in a particular central station.

"Centralized Control Desirable for Single Boiler-Turbine-Generator Units" was the title of a paper by **J. A. Lind** and **J. M. Geiger** of the Niagara Mohawk Power Corp. Noting that electrical engineers have been able to progress further than mechanical engineers in centralizing controls for both overall power systems and central stations, the authors pointed to older stations in which division of responsibility contributed to poor operation when the mechanical control group was divorced from the electric control group. Coordination of these groups was aided by adding a steam header pressure gage in the electrical control room and a station load megawatt meter in the boiler control room. Intercommunication facilities also contributed to coordination of station operation.

The controls for a single boiler-turbine-generator unit permit an entirely new approach and present an opportunity for major improvements in centralized operation. In a station having two units with no mechanical or electrical interconnections except for transmission lines, consider, for example, that the load is to be changed. Both boilers are subjected to the conditions accompanying this change, and as the load on one unit is altered, pump outputs and firing rates must be changed, requiring adjustments in the output of pulverizers, feeders and feedwater regulators, some of which are automatic and others manual. Operators should know as quickly as possible the magnitude and speed of load change on the unit they are handling. There are three ways of speeding up this intelligence:

1. Duplicate instrumentation at locations of several operators.

2. Use of a public address system.

3. Location of all affected operations at one point.

Such factors as (*a*) cost, (*b*) suitability and conformity as an extension to an existing station, (*c*) allowable time to make necessary changes, (*d*) division of responsibility between operators and (*e*) expediency, must be taken into account in selecting the manner in which station intelligence is transmitted.

The Oswego Station of the authors' company was designed so that each unit is capable of operating over a wide load range with flexibility of control to meet variable system demands. The authors commented: "A conception, believed to be original, was that of a 'straight-line' organization for each unit, originating with a 'unit operator' who would be in a position to supervise all operations of one boiler–turbine-generator unit. Normally he would control input to suit output, but he would also control output to not exceed the capability of the unit and its associated equipment."

The intent at the Oswego Station was to centralize control of all functions which require adjustment for safe and dependable operation over the normal load range of each machine. There was also provision for emergency shutdown. In a new station now under construction for the same company, "unit operators" will also be used, and they will be trained to operate both electrical and mechanical controls, permitting maximum flexibility of manpower in times of trouble.

The authors concluded with the thought that ten years' experience with two units at Oswego has confirmed the desirability of centralized controls in generating stations having single boiler–turbine-generator units. With the use of the more complicated reheat system, even greater benefits are foreseen for centralized control.

John M. Drabelle delivered a paper entitled "Centralized Control in Central Western Power Stations" in which he contrasted operation of central stations of the North Central Western states with those of the Metropolitan Eastern areas. In the former, prevailing turbine sizes range between 7500 kw to 20,000 kw, with a few larger machines. For this type of service the unit type of station, consisting of one boiler, one turbine and the centralization of electrical and mechanical controls, has the following advantages, all of which contribute to lower investment and operating costs:

(1) The elimination of the costly maze of interconnecting piping and valves.

(2) The costly intermediate electrical gear, together with its attendant rupturing-capacity problem, is not required.

(3) A simplification of the boiler feedwater problem as trouble with feedwater in one unit is confined to that unit.

Mr. Drabelle offered as a basic concept of centralized control, the centralization in one position of (*a*) the turbine, electrical controls, transformers, transmission lines, auxiliaries and switchgear; (*b*) hydrogen control, where required; (*c*) mechanical steam panel, including instruments for the feedwater heating cycle and extraction heaters, and controls for circulating, hotwell and drain pumps; (*d*) combustion control panel. In this manner all of the essential operations of the steam generating and steam utilizing equipment, auxiliaries, and electrical and transmission lines are located in one place under the supervision of one operator. This results in labor economy by eliminating those who would otherwise be required to be in attendance at widely scattered operating and control positions. Closest possible coordination between the designer and those responsible for operation is essential for the design and construction of a centralized control room having a convenient and accessible arrangement.

Discussion

The several papers on centralized station control evoked considerable discussion. It was stated that centralized control is an inevitable result of the complications inherent in the use of higher steam temperatures and pressures in central station design. There are dangers in advocating centralized control merely because it is the present "pattern" to do so; more important considerations are justifiable economic investments in control equipment and the ability of operators to comprehend quickly in emergency situations. These are matters that must be decided on an individual station basis.

A representative from one consulting engineering organization reported that a control board has been designed using pictorial representations of plant equipment and certain airplane-type instruments. Another consultant referred to the physical problem of finding a suitable location for centralized control, particularly in stations having capacities in excess of 30,000 kw, where it may be necessary to add a costly section equivalent to the entire height of the plant.

Mention was made that one advantage of centralized control where operators are accustomed to handling both the mechanical and electrical controls is that the men find their work more interesting because of its diversity.

Nuclear Power Plant Control

"Control Problems of a Power Producing Nuclear Reactor" was the title of a paper presented by **J. M. Harrer** of the Argonne National Laboratory. One watt of power is released in a nuclear reactor for every 30,000,000,000 (3×10^{10}) fissions occurring per second. There are also one to three neutrons released per fission in addition to heat, and these are used to continue the reaction. Reactor power is proportional to neutron density and to a constant that is dependent upon the size and amount of fissionable material in the reactor.

To generate useful power the heat source must be ready to deliver upon demand, fluctuations or shutdowns being held to a minimum. A control system is necessary to accomplish this and to prevent a heat production rate sufficiently high to damage the reactor. Since neutron density is a direct measure of reactor power, it is the most suitable parameter for controlling reactor power output.

The overall control system includes a power demand system, which is derived from conventional instruments, and a neutron density loop which matches the reactor power generated to the demand of the steam system, the latter being obtained from the power reactor by means of a heat-exchanger. The duty of an automatic control system for a power system is to hold the neutron density changes and magnitudes within safe limits and to prevent the operation, except in emergencies, of the safety rod system which is designed to avoid damage to the reactor in case heat is generated faster than it can be removed by the coolant.

Design factors with which the control engineer must contend include ruggedness, material depletion, size, and instrument period. Compromises must be made to achieve satisfactory overall control effects. The neutron density control loop involves the use of servomechanisms to move control rods which are made of boron steel or cadmium. There are indications that the power required to drive them will be in excess of the usual range of servomechanisms. Possibilities of reducing this power lie in the development of lighter rods, shorter strokes (more absorbent rods) and the making of greater allowable reactor power excursion or deviation, thus reducing the frequency response of the control system.

Hydrogen-Cooled Generators

Under the title, "Loading of Hydrogen-Cooled Generators at Elevated Gas Pressures," **D. S. Snell** of the General Electric Company presented a paper discussing the heating characteristics of hydrogen-cooled generators. To date relatively little information has been published on the operation of generators at increased hydrogen pressures, although such use of machines is now quite general. Data for estimating gains in rating obtainable by operation under these conditions were presented in the paper, along with an analysis of the practical limits to which hydrogen pressure may be increased.

One of the most important advantages of hydrogen cooling of electrical machinery is the ability to secure additional kva output by increasing the operating hydrogen pressure. This causes an increase in hydrogen density, resulting in an increased capacity to absorb and remove heat. Thus an increased kva output may be obtained for the same winding temperature. This is an important consideration inasmuch as the output of a generator is limited mainly by the heating of its windings.

In his analysis Mr. Snell showed that the assumption of a constant temperature rise of the windings as a basis for determining the output of a generator at elevated pressures is unrealistic. He suggested that a better basis for determining generator output is the stipulation of constant total temperature of the winding with maintenance of constant temperature of the ingoing cooling water. The studies made on this basis indicated that in most cases the output of a generator at elevated hydrogen pressures will be limited by the heating of the armature copper rather than by the heating of the rotor winding.

The Hydraulics of Steam Power Plant Design

At the Ninety-Seventh Annual Meeting of the American Society of Civil Engineers held at the Hotel Commodore in New York City on January 18–20 there were two papers sponsored by the Power Division of the A.S.C.E. that are worthy of consideration by engineers in the steam power field. One of these, which was prepared by Charles B. Seib of the Pennsylvania Power & Light Company, was entitled "Water Problems at Sunbury Steam Electric Station." The second was delivered by Allen W. Reid of Gilbert Associates, Inc., Reading, Pa., under the title of "Hydraulic Problems of Condensing Water Supply."

Sunbury Steam Electric Station

Mr. Seib's paper dealt with water problems encountered in the design and construction of the world's largest pulverized-anthracite-fired station located near Sunbury, Pa., at a point approximately three miles downstream from the junction of the North and West Branches of the Susquehanna River. Ultimate capacity for this station is 550,000 kw, of which 150,000 kw is now in operation and another 100,000 kw is currently being installed.

The water problems discussed are said to be typical of those encountered by hydraulic engineers who make preliminary investigations and undertake the design of any large steam-electric station located on a navigable stream. The Sunbury Station is designed for base load operation and obtains its entire water supply from the unregulated flow of the Susquehanna River. Condensing water requirements for the ultimate 550,000 kw capacity are 712 cfs, with an additional 65 cfs for service water, an amount approximating 500,000,000 gallons per day.

The Susquehanna River is the largest stream entering the Atlantic Ocean along the coast of the United States, having a drainage area at the plant site of 18,2000 sq miles, and is characterized by extreme variations in flow. The minimum value recorded in the years 1918–1945 was 1220 cfs, as contrasted to the March 1936 flood value of 556,000 cfs, which, incidentally, involved a change in elevation of nearly 30 ft with respect to low water level.

The water enters the station through intake bays in the river wall, passes through fixed trash racks consisting of a series of steel bars from which refuse is removed by a mechanical rake, then goes through revolving screens for removal of finer material, and passes into a common water chamber where a chlorine solution is injected periodically to prevent the accumulation of algae and organic growth in the tunnels, piping and condensers. It then flows by gravity through two concrete intake tunnels, from which it is supplied to the condensers by means of horizontal double-suction centrifugal pumps. From the condensers the water is carried into discharge tunnels where it re-enters the river about 75 ft downstream from the intake.

In order to prevent uncontrolled recirculation, a low gravity-type concrete dam was constructed across the river between the intake and discharge. Provision is also made to raise the temperature of the water entering the intake structure to prevent adherence of frazil and anchor ice to the trash racks and revolving screens. To accomplish this a recirculating pump takes warmed water from the discharge tunnels and discharges it through orifices in the top and bottom of the intake openings, mixing it with the incoming river water to raise the temperature sufficiently for preventing ice formation.

For condensers, heat-exchangers, ash sluicing and revolving screen washing, raw river water(chlorinated for algae control, as previously noted) is used. All other equipment cooling water is in a closed system with makeup taken from the condensate system employing a heat-exchanger through which raw river water is passed as a cooling medium. Boiler makeup is coagulated, filtered, softened, evaporated and deaerated. The water treatment plant is served by one 725-gpm raw water pump which, along with two 2000-gpm ash water pumps, is located in the turbine room basement. Equipment for coagulating, filtering, softening and chlorinating is located in a separate building. There are two 200-gpm reactivators from which effluent flows to two of the three 200-gpm anthracite gravity filters, and from there it is pumped to a 500,000-gallon steel standpipe. Four filtered water pumps deliver water from the standpipe to the filtered water system and to two vertical zeolite softeners of the downflow pressure type, rated at 470 gpm and employing a carbonaceous base mineral as an exchange material. The water not intended for sanitary or potable use then passes through evaporators before entering the condensate system as makeup.

Mr. Reid of Gilbert Associates, Inc., based his paper on actual studies made in connection with the design and construction of nearly a dozen central stations. Condensing water supply may not be a major factor in selecting a steam-electric plant site so long as it presents no insurmountable problems. However, when the adequacy of the supply is not obvious, the engineer must make studies to determine the amount of available water and the justifiable installation size. Once a site has been selected, he is expected to devise the most efficient and economical means of employing the water.

An interesting sidelight on water supply is that, as a result of seasonal load distribution, water shortages may be far more harmful in November and December than in August and September, notwithstanding the offsetting effect of lower natural water temperatures in the former months. For systems having well-supplied hydro storage capacity, condensing water deficiencies may not be harmful if they are infrequent and short lived.

In considering power plant gains due to higher steam pressures and temperatures, sight is often lost of the condensing phase of the thermal cycle. The accompanying quotation is revealing in this connection:

"Improvements in design and changes in practice during the past 25 years have reduced the quantity of condensing water required per kilowatt of capacity from 1.5 gpm or more to about 0.5 gpm in the case of some recent installations incorporating the reheat cycle. This fact may become important when we are considering an addition to an existing station containing old units which are still required to meet load demands. A shortage of condensing water will cause a proportionate reduction in capacity far less, in this case, than it would in an all new plant."

Related Problems

In the design of structures for handling condensing water it is important to know both the ordinary and extreme range of water elevations. Traveling screens must always be accessible, with their operating mechanism above water. In the case of plants located where fuel may be received by ship or barge, insufficient attention is often given to possibility of recirculation. A related problem concerns the design of discharge tunnels to avoid objectionable currents and building up of silt deposits.

The advantages of closed conduits for stations located some distance from the edge of a stream can be appreciated when it is understood that in times of high flow the velocity in the conduit may be maintained equal to that in the main stream, whereas with an open channel the velocity becomes negligible, resulting in the deposition of most of the material carried in suspension.

On smaller rivers there exists the problem of obtaining the highest possible percentage of stream flow through the condensers. In these cases, it is desirable to study carefully the physical condition of the stream at low stages with a view to taking advantage, wherever possible, of a shoal as a natural dam. In any event, if a dam is not required for the initial development, it may be wise to take account of the possibility of its later construction by locating inlet and discharge structures so that this step may be taken without undue complication. When conditions permit, it is more economical to make the intake tunnel very short and to obtain necessary separation through a long discharge tunnel.

Where there is an exceptionally large differential between maximum and minimum water levels, one technique that has been successfully employed is the use of a hydraulic turbine driving a booster pump in series with the main circulating water pump. Combined efficiencies of the hydraulic units in a plant built on the Ohio River about 1944 are reported to enable the recovery of between seventy and eighty per cent of the power which would otherwise be wasted.

Mr. Reid expressed the opinion that hydraulic problems of condensing water supply have not received sufficient open discusion in technical society circles. He noted that little or no mention of such problems had been made in published descriptions of steam plant projects and expressed the hope that additional attention would be accorded to them in the future.

Discussion

During the discussion of this paper mention was made of problems encountered in handling condensing water because of the presence of numerous small fish, where an electric screen proved effective, and of difficulties resulting from marine fouling where sea water is the condensing medium. Reference was made to the series of papers on this subject delivered before the 1949 A.S.M.E. Spring Meeting at New London, Conn.[1] While Mr. Reid's paper did not consider the use of cooling towers for handling condensing water, a discusser reported that one engineering organization alone had installed approximately 600,000 kw of capacity using this form of cooling. Still another engineer reported that consideration is being given to the reclaiming of water from sewage for reuse in process, and it was indicated that one Eastern steel plant is recovering over 40,000,000 gallons per day from a municipal sewage plant. There was general agreement that insufficient attention has been given to the function of the hydraulic engineer in the design of steam-electric power stations.

1. COMBUSTION, Vol. 20, May 1949, p. 46-47.

Research on Steam Contamination

Jointly sponsored by two electric light and power associations, three turbine manufacturers and three boiler manufacturers, a research project on steam contamination and turbine deposits by Armour Research Foundation of Illinois Institute of Technology is now entering its third year. Activities of the first year consisted of literature surveys, analysis of turbine-deposit surveys, investigation of methods of silica analysis, followed by power plant inspections.

Research is now being conducted on the adherence of siliceous materials to metals. Deposition apparatus has been constructed and installed in a large midwest power station. With this apparatus it is possible to investigate factors affecting deposition as well as to evaluate possible means of preventing it, such as the use of different metallic surfaces or treated surfaces, and the injection of various surface active materials into the steam.

Several promising methods of adapting the spectrophotometric method of silica test to the determination of total silica are being investigated.

Apparatus has been designed and will be constructed to determine the solubility of silica in high-pressure steam in a non-flow system.

The collection of deposits and pertinent data from selected power plants will be continued. Tests to determine the propensity toward deposition in the turbine are also being developed.

Program of Twelfth Midwest Power Conference

A THREE-DAY meeting of the Midwest Power Conference centered around the theme "Economy in Power" will be held at the Sherman Hotel in Chicago on April 5, 6 and 7, 1950. A total of 26 sessions including three luncheons and the "All Engineer's Dinner" are scheduled for the program. More than 50 papers will be presented by leading authorities in practically every phase of the power industry.

As in former years, the conference is sponsored by the Illinois Institute of Technology in cooperation with nine Midwestern Universities and nine local and National engineering societies. The preliminary program follows.

WEDNESDAY, APRIL 5

8:30 a.m. Registration, Sherman Hotel.
10:30 a.m. Opening Meeting.
12:15 p.m. Joint Luncheon with A.S.M.E.
2:00 p.m. Steam Generation Equipment Session, E. C. Bailey, Chairman.

"Use of Model to Study Steam Separation in Boilers," by Erich Farber, University of Wisconsin.

"The Dual Circulation Boiler," by R. A. Lorenzini, Foster Wheeler Corporation.

2:00 p.m. Electrical Equipment Session, E. T. B. Gross, chairman.

"An Appraisal of Power Transformer Design Progress," by W. Gordon James, Westinghouse Electric Corporation.

"Modern Type High-Power Circuit-Breakers," by Robert H. Nau, University of Illinois.

3:30 p.m. Feedwater Treatment Session No. 1, M. P. Cleghorn, chairman.

"Demineralization Compared with Evaporation of Makeup for High-Pressure Condensing Power Plants," by J. D. Yoder, The Permutit Company.

"Applying Steam Lift Circulation to Hot-Process Softeners and Deaerators," by A. A. Kalinske and J. M. Kahn, Infilco Inc.

3:30 p.m. Fuels Session, M. A. Faucett, chairman.

"Coal's Place in the Sun," by Bertrand A. Landry, Battelle Memorial Institute.

"Liquid Fuels from Oil Shale," by Boyd Guthrie, Chief, Oil-Shale Demonstration Plant, Rifle, Colorado.

3:30 p.m. System Planning and Design Session, E. B. Kurtz, chairman.

"Circuit Interruption by Means of High-Voltage Air Switches," (with film), by S. C. Killian, Delta Star Electric Co.

"Safety in Substation Design," by J. O. Leslie and D. L. Greene, Gilbert Associates, Inc.

THURSDAY, APRIL 6

9:00 a.m. Feedwater Treatment Session, No. 2—Symposium on Magnetic Iron Oxide Deposits, R. T. Hanlon, chairman.

"Experimental Studies of Iron Oxide Deposits in Boilers," by C. Jaklin and W. H. Thompson, National Aluminate Corporation.

"Steel, Heat and Water: Localized Formation of Magnetic Iron Oxide in Power Boilers," by H. M. Rivers and W. M. Sonnett, Hall Laboratories, Inc.

"Magnetic Iron Oxide Deposits in a 420-psi Boiler," by J. H. Moore, Otter Tail Power Company.

"Causes and Prevention of Iron Oxide in Boilers," by S. T. Powell, L. G. von Lossberg, and J. K. Rummel.

"Prevention of Black Iron Oxide Deposits Following Chemical Cleaning," by P. H. Cardwell, Dowell Inc.

9:00 a.m. Power System Operation Session, V. I. Easterday, chairman. (Sponsored and arranged by Power Group, Chicago Section A.I.E.E.)

"Control of Power Flow on Interconnected Systems," by Nathan Cohn, Leeds & Northrup Company.

"What Reserves Should Be Provided in a Modern Power System?" by Howard P. Seelye, The Detroit Edison Company.

10:30 a.m. General Session on Rural Electrification, E. W. Kimbark, chairman.

"A New Approach in Utility Cooperation with R.E.A.," by John M. Drabelle, Iowa Electric Light and Power Company.

"Cooperation Between Electric Companies and Cooperatives," by Edwin Vennard, Middle West Service Company.

12:15 p.m. Joint Luncheon with A.I.E.E. H. E. Nason, chairman. Speaker: J. H. Jewell, Westinghouse Electric Corporation.

2:00 p.m. Central Station Plants, R. C. Porter, chairman.

"Recent Improvements in Central Station Equipment," by G. A. Gaffert, Sargent & Lundy.

"Modern Steam Turbine Developments," by J. R. Carlson, Westinghouse Electric Corporation.

2:00 p.m. Small Power Plants Session, Glen E. Copeland, chairman, Capitol Bldg., St. Paul, Minn. (Sponsored and arranged by the N.A.-P.E.)

"Comparative Costs of Fabrication of Industrial Piping," by Charles Schott, Chief Engineer, Frank Fehr Brewing Company.

"Power Plant Operating Costs," by O. L. Beiswenger, consulting engineer.

2:00 p.m. Industrial Applications of Electrical Energy, H. L. Decker, chairman. (Sponsored by Industrial Group, Chicago Section A.I.E.E.)

"Conversion of Electrical Energy by Mechanical Means," by Otto Jensen, I-T-E Circuit Breaker Company.

"Electric Power Distribution Systems for Typical Industrial Plants," by S. L. Chapin, Sargent & Lundy.

3:30 p.m. Electronics Application, H. J. McCreary, chairman. (Sponsored and arranged by Electronics Group, Chicago Section A.I.E.E.)

"Factors Affecting the Use of Electronic Instruments by the Power Industry," by George E. Foster, Metrotype Corporation.

"Electronic Loading for Boiler Control," by Charles Smoot, Jr., Republic Flow Meters Company.

3:30 p.m. Power Plant Design and Construction Session, Ben. G. Elliott, chairman.

"Trends in Power Plant Design and Construction," by Paul Gordon, Ebasco Services Inc.

"Basic Factors in Steam Station Design," by B. C. Mallory, Stone & Webster Engineering Corporation.

3:30 p.m. Miscellaneous Steam Applications, Dean L. G. Miller, chairman.

"Feedwater Heating and Deaeration," by A. E. Kittredge, Cochrane Corporation.

"Steam Services to Central Station Districts," by Glenn D. Winans, The Detroit Edison Company.

6:30 p.m. All Engineers Dinner.

FRIDAY, APRIL 7

9:00 a.m. Symposium on Atmospheric Pollution, Louis C. McCabe, chairman.

Frank A. Chambers, Chief Smoke Inspector, Department of Smoke Abatement and Inspection, Chicago. (Subject to be announced.)

"Technical Aspects of Air Pollution Abatement," by A. D. Singh, president, Singh Company, Chicago.

"Smoke Abatement Engineering," by H. B. Lammers, Coal Producers Committee for Smoke Abatement.

"Field and Laboratory Methods of Air Pollution Study," by Paul L. Magill, Stanford Research Institute.

9:00 a.m. Panel Discussion on Diesel Engine Maintenance, W. P. Green, chairman. Sponsored by Diesel Engine Manufacturers Association with the following speakers:

D. H. Queeney, general service manager, Electro-Motive Division, General Motors Corporation.

Raymond McBrian, vice president, Denver and Rio Grande Western Railroad Co.

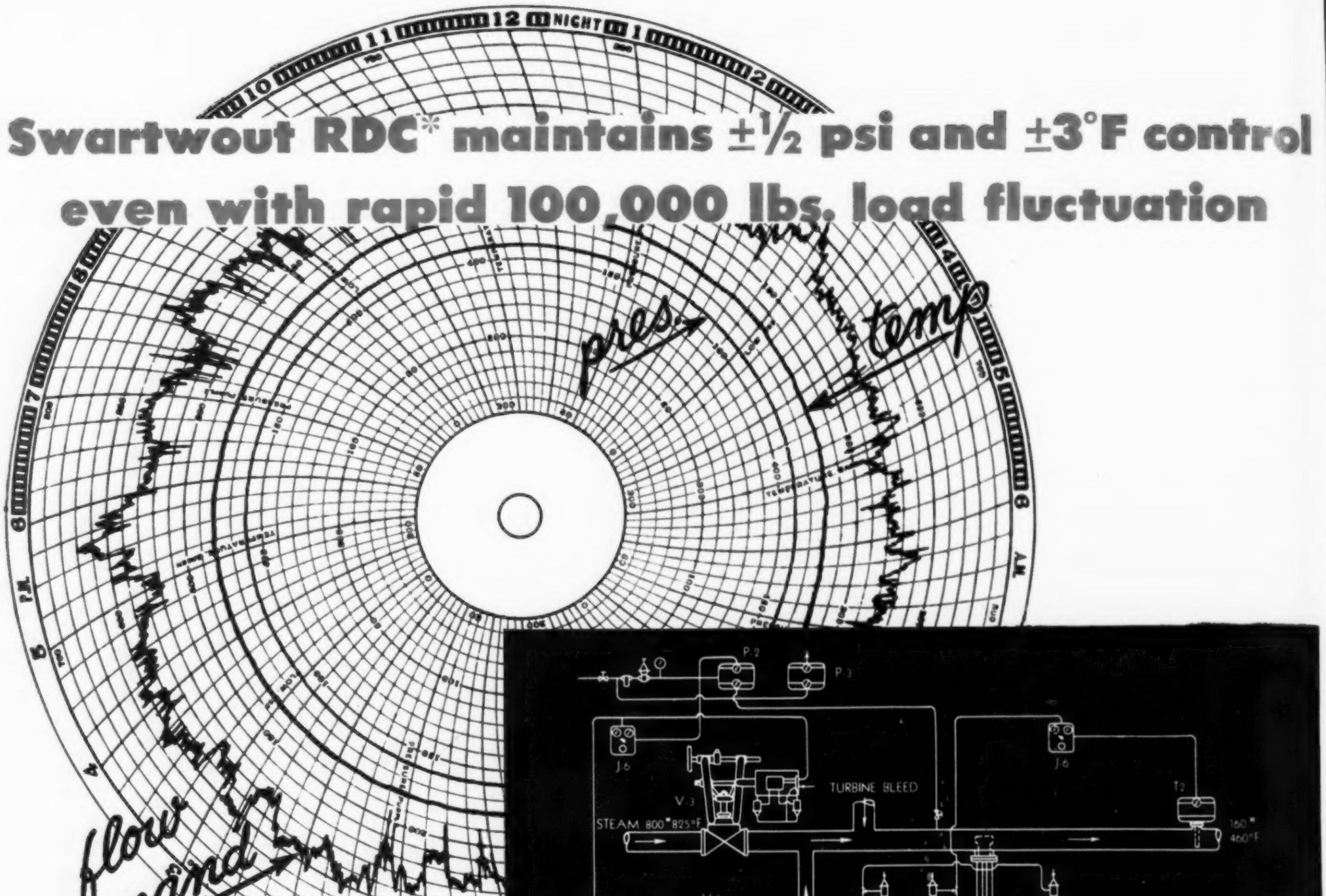
James E. Justus, manager, Diesel Locomotive Service, Fairbanks Morse and Company, Beloit, Wis.

9:00 a.m. Heat Pump Session, J. W. Andeen, chairman.

"Standards of Performance for Heat Pump Cycles," by John F. Sandfort, Iowa State College.

"Earth Heat Pump Research" by Estel B. Penrod, University of Kentucky.

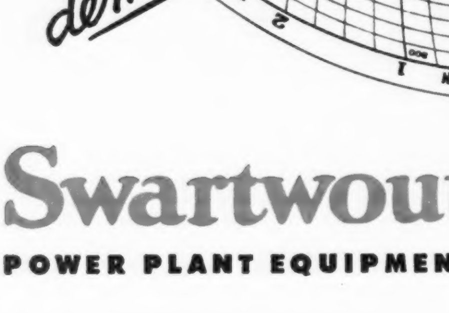
Swartwout RDC* maintains ±½ psi and ±3°F control even with rapid 100,000 lbs. load fluctuation



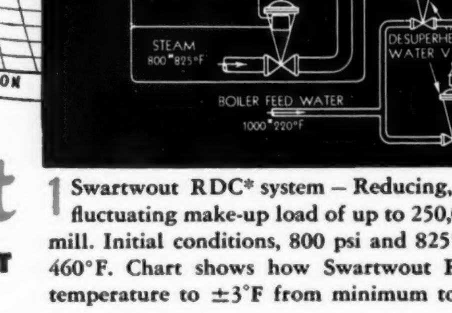
Swartwout

POWER PLANT EQUIPMENT

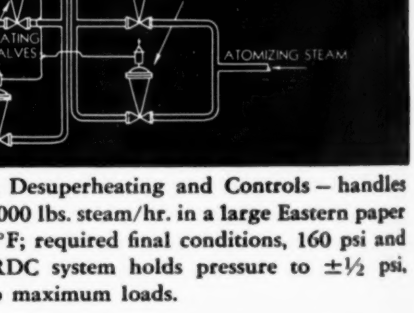
1 Swartwout RDC* system – Reducing, Desuperheating and Controls – handles fluctuating make-up load of up to 250,000 lbs. steam/hr. in a large Eastern paper mill. Initial conditions, 800 psi and 825°F; required final conditions, 160 psi and 460°F. Chart shows how Swartwout RDC system holds pressure to ±½ psi, temperature to ±3°F from minimum to maximum loads.



2 Swartwout V-1 valve *(above)* handles first 50,000 lbs. of load; V-3 then cuts in to handle 200,000 lbs. additional load. Valves reduce pressure from 800 to 160 psi without turbulence, vibration or undue noise. Correct design of disc, seat and throat eliminates high-velocity impingement and other destructive forces common to conventional reducing valves.



3 Swartwout steam atomizing desuperheater drops live steam temperature from 825°F, and varying extraction temperatures, to 460°F without pressure loss. Smooth-finished nozzle passages disperse atomized water outside head so that no erosion occurs. Narrow-angle atomization prevents thermal strains or cracks in piping, eliminates need for pipe liners.



4 Swartwout T2 direct-contact master control with reset for load compensation, sends temperature-proportional air-loading pressure through J-6 manual-automatic selector panel. Response to temperature change, within fraction of a second, assures precise temperature control regardless of load fluctuation or time lag. A-2769

SEND FOR BULLETINS S-21-E, S-22-C, S-198 • THE SWARTWOUT COMPANY, 18511 EUCLID AVENUE, CLEVELAND 12, OHIO

10:30 a.m. Heating and Air Conditioning Session, J. D. Pierce, chairman.

"Heating of Basementless Houses with Warm Air," by C. W. Nessell, Minneapolis-Honeywell Regulating Company.

"Development of Turbine-Driven Centrifugal Refrigeration Machines and the Water Absorption Machine," by O. E. Gammill, Jr., Carrier Corporation.

12:15 p.m. Joint Luncheon with W.S.E.

2:00 p.m. Gas Turbine Locomotives, J. T. Rettaliata, chairman.

"A 4000-Hp Gas Turbine Locomotive for Passenger Service," by T. J. Putz, Westinghouse Electric Corporation.

"A Coal-Burning Gas Turbine for Locomotive Service," by W. B. Tucker, Allis-Chalmers Manufacturing Co.

"Progress Report of Coal-Burning Gas-Turbine Locomotive," by J. Y. Yellott, Locomotive Development Committee.

2:00 p.m. Feedwater Treatment Session, No. 3.

"Water Treatment for Modern Electric Utility Plant Installations," by F. G. Straub, University of Illinois.

"Prevention of Deposits in Closed Feedwater Heaters and Economizers," by Warren S. Kane, Iowa Public Service Company.

2:00 p.m. Relay Testing Practices, E. L. Michelson, chairman.

"Relay Maintenance in a Metropolitan Power System," by J. W. Smith, Commonwealth Edison Company.

"Relay Testing Practices in a Power Company Serving a Large Area," by V. E. Verral, Central Illinois Public Service Company.

A Close-Up View of Conditions in the Coal Fields

Apropos of the present fuel situation and conflicting reports as to conditions in the coal fields and the attitude of the miners, we are privileged to afford readers some insight into the matter through the following excerpts from a personal letter written by a clergyman located in the heart of the Pennsylvania coal fields, whose work brings him in close contact with the miners. The letter, written on January 9, was not intended for publication, but at our request the author has kindly consented to our doing so. For obvious reasons we have omitted his name.—Editor.

"The coal situation hasn't cleared appreciably, nor does there seem to be much hope for early improvement. Mr. Lewis appears bent on something (the like of which I fail to understand), and he still has the sort of prestige that enables him to command allegiance from his men—come what may. Certainly the situation does not stem from any pressure from within the ranks of the miners. Frankly, they are sick. Since July first, the expiration date of their last contract, they have scarcely been able to keep ahead of the bill collectors. In fact, conditions have been so uncertain that they have hardly been able to do much more than care for their food bills. And that they don't like.

"It must be remembered that for the

preceding ten years their work had been pretty steady. They could count on an average of $4^1/_2$ working days each week with a steadily rising level of wages. Consequently their pockets have been well filled; but not so today. Their savings have been liquidated; their bonds cashed; and there is an increasing number of needy cases. And all of it is directly attributable to Mr. Lewis. What he hopes to gain for his men I cannot understand.

"Mr. Lewis must realize that the large demand for American coal overseas has gone, with little chance of returning, and that the mines today can produce far more coal than our industry needs. At the same time, he must realize that living conditions and salary levels in the coal fields are on a par with those of other major industries. He must realize also the opposition that has been marshalled against him in public opinion, the competition with other more salable fuels, as well as the direct opposition from the mine operators themselves.

"What he expects, I cannot say; and yet we must remember that for more than twenty years Mr. Lewis has been a sort of dictator in the coal fields, and his word today goes almost undisputed. For during all that time he has been at the eternal job of hammering for higher pay and better working conditions, and has never been refused successfully. This has established a pattern that is hard to buck. As a matter of fact, if it were broken he might lose the support of his men.

"It appears that Mr. Lewis may push his success to such a point that it will either collapse of its own weight, or by wrecking the industry the same situation would be brought about. At any rate, the man who digs the coal stands to lose. But apparently Mr. Lewis doesn't care so long as he makes headlines and gratifies his own ego. If I seem a bit bitter, it is because I've seen too many homes go hungry for no intelligent reason.

"I realize that I must qualify what has just been said. Mr. Lewis and organized labor have been of infinite aid to the miner, in that they have given him a position comparable with workers in other major industries. The average miner today owns his home, a car, and most of the niceties that go with our present-day civilization. That is fine; but at the same time, it hasn't taught him that his job is an honorable one of which he should be proud. He still grumbles and seeks pity. He finds expression for this in his union and thereby lays himself open to exploitation at the hands of union leaders. Time was when the miner needed protection from mine operators; today he needs protection from the union and from a set of arbitrary decisions which he has had no part in making and which at any time may take away his right to work.

"I am a firm advocate of organized labor, but a confirmed enemy of nationally dominated labor movements. I do not believe in a labor monopoly any more than I do in an oil monopoly, or that of any other commodity. To the lay mind it seems a shame that the same legal instruments that were effective against business monopolies cannot be used with similar effectiveness against labor monopolies."

Femininity Visits a Power Station

Recently two young ladies from Combustion Engineering-Superheater, Inc., Miss Dorothy Devaney and Miss Iris Chekenian, took advantage of an opportunity to visit the new high-pressure, high-temperature Sewaren Generating Station of the Public Service Electric and Gas Company. Presumably, their object was to see, at first hand, something of the equipment about which they had often had occasion to handle correspondence. Upon their return, Miss Chekenian prepared a memorandum of their impressions. This, by chance, came to the attention of the Editor of COMBUSTION who decided to share this treat with the readers

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The writer with other members of the party met in the small but charming lobby of the Station, from which small groups of eight to ten persons were conducted to the turbine room. The turbines and generators were painted light green and blended very nicely with the yellow feedwater heaters. Conversation during the inspection of this portion of the plant was difficult because of excessive noise. One of the units was a Westinghouse machine, and the other two were General Electric. We noted very negligible differences in these turbines and generators, and it is suggested that Public Service buy all such equipment hereafter from the same company. Cost would be diminished at cut-rate prices, and it would provide for more symmetry in external appearance.

From there we proceeded to a balcony and viewed the pile of coal which had passed through its first stage of crushing. We understand that the preliminary crushing is to ease the work on the pulverizers, and after the coal is passed through the pulverizers, it is as fine and soft as face powder. The conveyor belt was rather impressive, but it was not working at the time.

On the right was a muddy river which is a great convenience for the boats carrying oil to the station. On the left was an old tin shack with a few people sitting in it and figuring how much money they would be saving on the natural gas that was being piped in from Texas. We were in complete agreement with whoever thought up the idea of building a plant with facilities for burning coal, natural gas or oil. The factor determining the type of fuel to be burned is cost. What else?

The party then returned to the turbine room, and following approval of the various displays showing cross-sections of turbines, generators, condensers and exciters, we inspected the burners. The fuel pipes showed they were nicely kept and free of dust. We were told about the tilting burners, which seem to have an effect in the control of superheat, and informed as to their placement and the essentials of tangential corner firing.

About fifteen feet from the fuel pipes, the author's company has erected a glorious display, showing a cross-section action view of the boiler in technicolor. It seems unnecessary to go into the details of the boiler at this point.

"The light was almost blinding"

(with apologies by the artist)

The pulverizers were inspected, and they too were very noisy because each box holds 22 tons of steel balls, approximately the size of golf balls, and they continuously jump around and crush the coal. Of course they crush themselves at times.

We then turned to the soot blowers, saw the control room, which looked very confusing, and returned finally to the pulverizers from which point we looked up and saw the silvery bottom of the boiler.

We were then met by a new guide who took us upstairs. We stood near the two upper drums; were told that the water level was approximately the same in both; informed of their respective functions; and then proceeded to inspection of the superheater outlet header. From that point, we missed seeing the first and second stage superheaters, the economizer and the air heater. A survey of these parts, therefore, and a discussion of the transformation of saturated steam to dry steam will have to be made in a later report.

We then took a walk outside on the balcony, partaking of the fresh air and viewing the scenic swamplands of North Jersey. We were duly amazed at the construction of the boiler, more specifically at the idea of building half of it indoors and the rest outside. Workers suffering from the cold need only to jump inside for a few minutes to warm up.

Looking cautiously through the peephole, we at last saw the waterwall tubes. The light was almost blinding, but we were able to make out the forms of many tall skinny tubes, whitish orange in color, and noted apparently very little deposit of slag. We closed the peephole right away because it was very hot in there and groped our way down to the next landing in a state of complete amazement and awe, and with great fear looked through another peephole. Here we saw the fire, the four burners in one corner, and an immense hole. The gaping hole with the fire in it was bigger than anything we had expected. The outer casing of the boiler, incidentally, is cool.

On the fifth floor we were escorted into the erection offices of Combustion. The luxurious office was supported by a few rough beams, bare wooden walls, and was furnished with a desk of questionable origin and a three-legged chair.

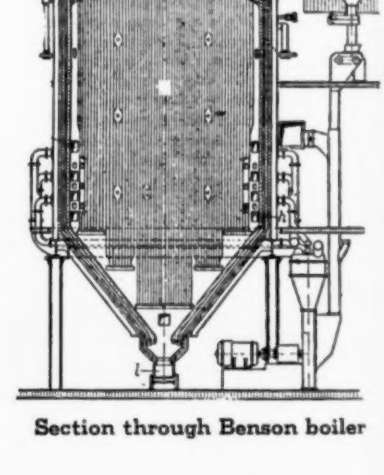
Stepping into the self-service elevator once more, we arrived at the main floor, surveyed the bin used for the purpose of collecting molten slag, and the other bin in which it is water cooled, and the big pipe which disposes of it.

Following examination of the tremendous stainless steel door which we understand cost $50,000, and with a final look around, we sadly took our leave of what to us appeared the greatest power plant in the world, with only one last thought—that it sure is going to a hell of a lot of trouble to boil some water.

Our last words are the hope that secretaries will be able to go on these tours more often.

Rehabilitation of Berlin-West Generating Station

Reconstruction of the Berlin-West generating station is discussed in several foreign technical publications. The original station, which was placed in service in the years 1930–32, consisted of eight stoker-fired boilers each with a capacity of 330,000 lb of steam per hour at 470 psig and 880 F, and six turbine-generators having individual ratings of 34,000 kw. A topping extension to the plant to consist of



Section through Benson boiler

four 350,000-lb per hr pulverized-coal-fired Benson boilers of 2000 psi and 932 F, employing reheat and topping turbine-generators, was begun in 1942. This had progressed to the point of completion of foundations and steelwork when the Russians occupied Berlin in 1945. The latter dismantled, carried away and eventually sold as scrap the whole of the existing plant, except the main boiler structures.

Little more than an empty shell existed when the British took over the western zone of Berlin. Two Benson boilers of all-welded construction, each having a capacity of 350,000 lb of steam per hour at 2000 psig and 932 F, along with one 26,000-kw high-pressure turbine-generator, were selected; in addition two 36,000-kw condensing units and one 12,000-kw house set, operating at 324 psig, 807 F were chosen. Financial difficulties and the Berlin blockage delayed boiler erection until May 1949. Since the foundations and buildings were already in place, this work proceeded rapidly, aided by a force

which at one time reached 2000 men. An interesting sidelight is that 1460 tons of equipment were transported by air during the blockade, many of the boiler tubes having had to be cut to meet space limitations of this means of transport. However, the high-pressure turbine-generator and one of the low-pressure units went into service in November 1949 and the second low-pressure unit was scheduled to go into operation late in January.

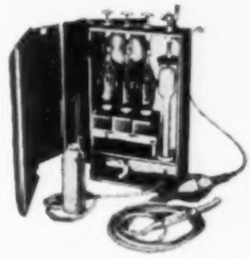
Automatic control from a control boiler-turbine control room is a feature of the station. To deal with rapidly fluctuating loads, two Ruth's steam accumulators have been installed in the low pressure steam system. Anticipated coal consumption is one lb per generated kwhr.

Caustic Cracking at Elevated Temperatures

A paper by C. D. Weir before The Institution of Mechanical Engineers (Great Britain) describes a series of tests conducted at the University of Glasgow to investigate caustic cracking of steel in the presence of sodium hydroxide solutions at high temperatures, to simulate, as far as possible, conditions in boiler practice. The specimens, of hollow form, were inserted into the base of an autoclave and loaded by means of a lever system, through a push rod inserted in the specimen. Briefly, the following results were observed:

1. It was found possible to produce failure of notched specimens rapidly and consistently, but homogeneously stressed specimens appeared to be immune.
2. All the fractures were intercrystalline and typical of those occurring in practice.
3. Dilute caustic solutions, although not entirely impotent, were found to be very much less effective than those of high concentration. However, one failure occurred with a solution as low as 7.6 per cent.
4. The presence or absence of silica in the solutions did not appear to exert appreciable influence; that is, pure sodium hydroxide was extremely effective in producing failure, and the addition of silica did not materially influence the results. This is at variance with results reported by Jenkins and Adcock in 1941 and by Schroeder and Berk (U. S. Bureau of Mines) in 1936.
5. Although some previous investigators had reported that tannin has the ability to reduce the incidence of cracking, the present tests failed to show that the addition of tannin, or the use of fine-grain steels were entirely effective in preventing intercrystalline failure; although in the case of the latter increased resistance was noted, particularly when slightly higher in carbon content.
6. Cathodic polarization was found to be protective, while anodic polarization did not prevent, and possibly hastened, failure.

The work is still in its initial stages and is being continued.



New Books

Any of these may be secured by writing Combustion Publishing Company, 200 Madison Avenue, New York 16, N. Y.

Technische Thermodynamik

By Dr.-Ing. Fr. Bošnjaković

Part I of the third edition of this book treats the fundamental aspects of technical thermodynamics. The subject matter includes discussions of energy concepts, and reversible and irreversible processes, Avogadro's theorem, Dalton's law, as well as the experiments of Joule and of Gay-Lussac, are described. Ideal gases, mixture of gases, the equations of state of van der Waal, and of Callender and Mollier are discussed. The properties of steam and the thermodynamic problems related to its generation and use are treated in detail. Refrigeration, combustion, and gas production are subjects for discussion. Other topics which are treated are flow of fluids and flow of heat.

In addition to the main portion of the text, table of contents and index, the book has a list of the symbols and abbreviations which are used. On separate sheets there is a group of exercises accompanied by their solutions. A small scale diagram for CO_2, another for NH_3, and a large-scale Mollier diagram for steam are included.

There are 245 figures interspersed in the text, all being line sketches. No photographs of industrial equipment are included among the illustrations. The paper is of poor quality and the printing does not leave enough space between the individual lines. Although most of the figures are clear, some of them have been reduced too much in size and are hard to read. This seems to be especially true for the pressure-volume, temperature-entropy diagrams, the enthalpy-entropy Mollier diagrams in the text, and the curves of specific heat.

This text adheres to fundamentals more than do the applied thermodynamic texts written in this country. Fr. Bošnjaković is a recognized authority in the field and an excellent teacher, if one is to judge from this book. The development of the subject is extremely clear. The German syntax should not present difficulties to the reader who can read some technical German.

The book contains 327 pages and sells for $5.95.

Engineering for Production

By Walter Ernst

Designers and shop men will find much in common in this book which contains many standards to improve drawing-room practice and to coordinate manufacturing operations. It is not generally recognized that just as interchangeable parts achieve economies in mass manufacturing, so may standardized procedures bring about significant cuts in drafting-room costs. The author, who is now director of engineering for Commonwealth Engineering Company, has done an excellent job in pointing out

how drawings made to common engineering standards aid in overcoming manufacturing difficulties.

Among the topics covered in this work are drawing sizes, dimensions, tolerances and fits, notes and symbols, castings and forgings, metals and heat treatment, thread connections, piping, gaskets and seals, keys and splines, gearing power transmissions, bearings, and electric motor standards. The book is $8^1/_2 \times 11$ in size and is bound in flexible fabrikoid with a spiral binding permitting use in a flat position. It covers approximately 2000 subjects, contains 290 design drawings and tables and sells for $10.00.

Frederic Alan Schaff

Frederic Alan Schaff, chairman of the board of Combustion Engineering-Superheater, Inc., died at his home in Bronxville, N. Y., on February 7, at the age of 65, following a protracted illness.

Widely known in both railway and power fields, Mr. Schaff was an officer or director of numerous companies manufacturing equipment for both fields. These included, besides Combustion Engineering-Superheater, Inc., Lima-Hamilton Corp., director; The Lummus Company, chairman and director; The Superheater Company, president and director; American Throttle Company, president and director; The Air Preheater Corp., chairman and director; Franklin Railway Supply Company, director; Combustion Publishing Company, president and director; and foreign affiliates of several of the above companies.

Mr. Schaff had a family background in the railroad industry, his father, Charles E. Schaff, having been vice president of the Big Four and the New York Central and later president of the M-K-T Railroad.

He attended Culver Military Academy and Purdue University, from which he graduated in mechanical engineering in 1907. He was a member of Sigma Chi fraternity, and was elected to Tau Beta Pi, an engineering honorary society. In June 1949, he was awarded the degree of Doctor of Engineering by Purdue University.

Following graduation he spent the next three years with the Boston & Albany Railroad and the New York Central Lines; joined the service department of Locomotive Superheater Company in 1913, later becoming assistant to the vice president, and in 1916, vice president. In 1930, he was elected president of The Superheater Company, successor to the Locomotive Superheater Company, and in 1933, also became president of Combustion Engineering Company, Inc. He was elected chairman of the board of the latter in 1940 and, upon merger of The Superheater Company and Combustion Engineering Company in January 1949, he became chairman of the board of the combined company.

During World War II, Mr. Schaff was appointed to the Office of Production Management, War Production Board and to the Federal Power Commission Board in Washington to handle priorities for power equipment.

Mr. Schaff was a Fellow of the A.S.M.E. and a member of the Iron & Steel Institute, Society of Naval Architects and Marine Engineers and the Newcomen Society. He also was a member of numerous clubs.

Immediate survivors are his wife, Mary Lee Schaff, and two daughters, Mrs. Albert B. Boardman II of Rye, New York, and Mrs. E. Austin Byrne of Mamaroneck, New York, and five grandchildren.

Business Notes

Dowell Inc., Tulsa, Okla., announces the promotion of L. B. Wilson from development engineer to general sales engineer, and the placing of its New York Office directly under its General Sales Department in Tulsa.

E. F. Drew & Co., New York, has appointed J. S. Beecher as a member of the Technical Department of its Power Chemicals Division.

Graver Water Conditioning Company has appointed three of its parent company's engineering representatives as its sales agents; namely, J. R. Fortune & Son, Detroit; The Stapp Engineering Co., Denver, and Process Equipment, Tulsa, Okla. It has also named Fred S. Renauld & Co. as its Los Angeles representative.

Combustion Engineering-Superheater, Inc., has made the following changes in its sales setup: Arthur Hunter, formerly assistant manager of the Philadelphia District Office, transferred to New York as assistant general sales manager; R. L. Riker from manager of the Proposition Department to an assistant general sales manager; G. P. Ellis from western manager to manager of the Washington, D. C., Office; and T. J. McGowan from the Washington, D. C., Office to the Philadelphia Office.

James A. Ford, sales manager of **Jerguson Gage & Valve Co.,** Somerville, Mass., has been elected vice president and a director of that company.

J. P. Stewart, vice president and manager of the Commercial Sales Division of **De Laval Steam Turbine Co.,** has been elected executive vice president. Other announced appointments are W. A. Reynolds, formerly manager of the IMO-De Laval Products Division, to be assistant to the president; and W. A. Newman, Jr., to be acting manager of the IMO-De Laval Products Division, in addition to his present duties as controller of the Company.

Don Allshouse, since 1928 advertising manager for **Northern Equipment Co.,** Erie, Pa., has also been named advertising manager for the **Vulcan Soot Blower Corp.,** DuBois, Pa. These two companies are now divisions of the **Continental Foundry & Machine Co.**

Peabody Engineering Corporation, New York, has appointed Stephen A. Sloan as manager of research and development.

The **Davis Regulator Company** of Chicago is celebrating its seventy-fifth anniversary this year. George C. Davis, son of the founder, has been active in the business for more than fifty years, during which time many types of steam pressure reducing valves and control devices have been developed.

Facts and Figures

Anthracite Institute is engaged in research on the use of anthracite in tobacco curing.

•

The vast T.V.A. System in the South accounted for approximately $5^1/_2$ per cent of the total power generated for public consumption last year.

•

"Rank" is a term used with reference to coal to indicate its geological age and not to denote its quality.

•

When chromates are employed to inhibit corrosion in idle boilers, a concentration of at least 200 ppm is recommended.

•

Silica in steam has, in at least one instance, been traced to fly ash having found its way into the water system supplying boiler feed.

•

The output of electric utilities passed the six billion kilowatt-hour mark in the week ending February 4, which was the highest on record to that date.

•

One ton of bituminous coal of average heating value is equivalent to approximately $4^1/_3$ barrels of crude oil.

•

Hydroxide alkalinity can be determined by titrating to the end point of phenolphthalein after precipitation the carbonates.

•

The first commercial three-wire lighting plant was dedicated by Thomas Edison at Sunbury, Pa., in 1883.

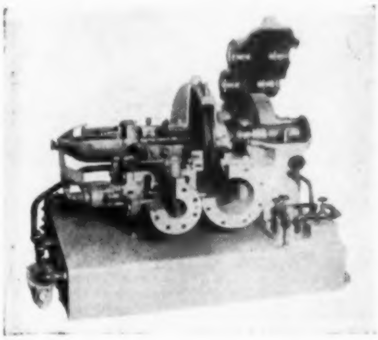
•

Two of the world's largest synchronous motors, of 65,000 hp each, were recently shipped by General Electric Company to the Bureau of Reclamation for use in the Columbia River Basin Irrigation Project at Grand Coulee Dam where they will drive pumps.

NEW EQUIPMENT

Gear Turbines

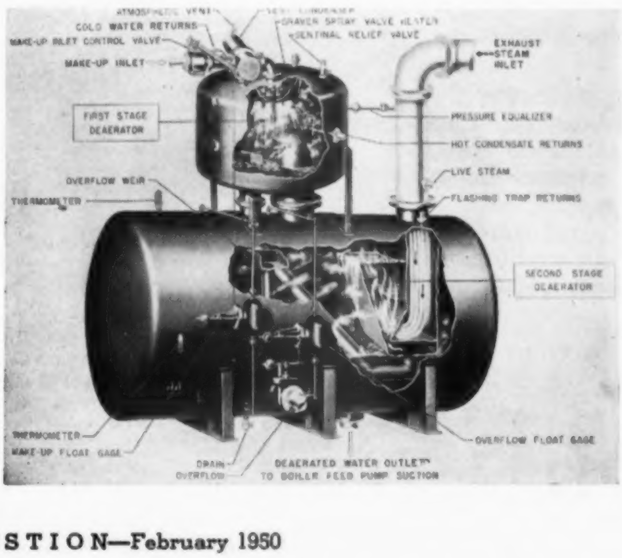
Westinghouse Electric Corp., Pittsburgh, Pa., has made available its Type E industrial steam turbine with close-coupled, integral reduction gears. The new units combine a compact speed-reduction mechanism solidly coupled to the turbine and operate as single pieces of



equipment suitable for driving pumps, fans, compressors and generators. Single helical gears with low helix angle give low thrust against bearings. Both turbine and gear are factory-aligned on a single, heavy-plate steel base which also serves as an oil tank. The units are available with standard gear reduction ratios for best operating speeds of the usual types of loads.

Deaerating Heater

Availability of a new two-stage deaerating heater design to reduce boiler-water oxygen content to less than 0.005 ml per liter under varying loads and unusual operating conditions is announced by Graver Water Conditioning Co., 216 W. 14th St., New York City. In this heater the special design of the spring-loaded, self-adjusting spray valves in the first stage causes heating of the incoming water to within two to four degrees of the steam so as to remove virtually all oxygen and free CO_2. In the second stage, the preheated water is mixed with an excess of incoming steam by means of scrubbing baffles. The steam carries with it the small traces of undissolved gases on its way to the first stage where it heats the incoming water. Complete deaeration is accomplished with minimum steam by means of the countercurrent flow of steam and water, and there are no moving parts within the heater. Units are available in sizes up to 2,000,000 lb per hr.



Forged-Steel Stop Valves

A new line of forged-steel stop valves built by Edward Valves, Inc., East Chicago, Ind., can be installed in most services where small steel globe or angle valves are used. Swing-bolted packing glands and large packing chambers make repacking extremely simple. Interchangeability of parts reduces maintenance inventories for the valves, which are available in sizes from $^1/_4$ in. through 2 in. with screened or socket welding ends. Built of carbon or chrome-moly steel for two ranges of service conditions, they are rated for 600 psi at 900 F and 1500 psi at 850 F for steam, oil and gas service.

Vari-Speed Drive

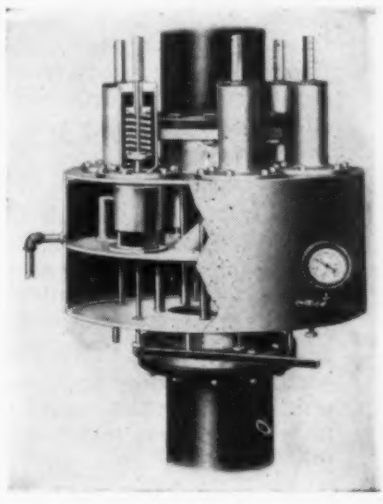
A new hydraulic control has been developed by Reeves Pulley Co., Columbus, Ind., for use on the Reeves Vari-speed Motodrive to provide a sensitive and accurate means of obtaining automatic speed changing. Tension, velocity, pressure, temperature and liquid level of materials in process may be controlled, and operating speeds of machines or parts of the same machines may be synchronized by this control. It consists of a self-contained hydraulic power plant and a simple rotary valve, piston and cylinder which are mounted as a unit on the Motodrive instead of the customary handwheel. The same control without the hydraulic power plant may be used for pneumatic operation with compressed air.

Tubular Dust Collector

A longer tube of relatively small diameter and having a single inlet slot for flue gases forms the basis of the Valmont Type S tubular dust collector design recently introduced by Prat-Daniel Corp., East Port Chester, Conn. The inlet slot materially reduces the distance a particle must travel before meeting the precipitating wall, and in the time required for the gases to travel the length of the tube it is claimed that a higher percentage of fine particles will be collected. The tubes of the dust collector are nested close together and are so arranged to set up an "S" shaped path which improves the aerodynamic flow of the gases and results in greater collection efficiency and the use of fewer tubes to handle equivalent quantities of gas.

Back-Pressure Valve

A new back-pressure valve has been developed and placed in production by Klipfel Valves, Inc., Division of Hamilton-Thomas Corp., Hamilton, Ohio. Made in two sizes, one for maintaining steam pressure between 0 and 20 psig and another for



vacuum service, the new valve is suitable for heating systems, power plants and process applications requiring close regulation of large quantities of steam. It is essentially an assembly of several single-port valves, each of which may be set to open in sequence, thereby minimizing hunting and wire drawing under pulsating flow conditions.